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ELIMINATING THE CONFLAGRATION HAZARD.

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[*Read March 14, 1900.*]

Mr. President and Gentlemen, — The subject noted on your program as assigned to me, "Fire Protection Afforded by Water Works," is a considerable one. The brief space of this paper is devoted to but a portion of the subject, yet one which is of the greatest importance; namely, the elimination of conflagrations in cities by the universal installation of automatic sprinkler systems which must obtain their chief supply from the public water-works system.

Conditions which allow a spread of fire from building to building exist in every city, town, and village of this country, and are responsible for a considerable part of the annual fire waste, amounting last year to over $150 000 000.

Such extensive fires are a drain upon the resources of the people, paralyze business locally, and to the insurance companies bring enormous and unusual loss, which it is impossible for them to accurately measure in the rate, that the burden of the insurance tax may be equitably distributed.

There is no question but what city buildings must adjoin or be in close proximity, must have numerous windows in walls and skylights in roofs, and a majority of them must contain inflammable contents to a greater or less degree. The danger is enhanced as the buildings grow in height, the congestion of values increasing with each added story, as well as the inability of the fire department to reach all parts of the building with their hose streams. Eight-story buildings and

"four-story fire departments" are frequently found in the same city. It should be realized that such portions of buildings as are beyond the reach of hose streams may be quite as much without fire protection as though located in the backwoods. Again, buildings have increased very much in area; many of them, located within the hearts of cities, being of enormous expanse, and, perhaps the worst feature of all, with their numerous floors punctured at short intervals by unenclosed light, air and elevator shafts and stairways, thus allowing a fire to quickly spread from floor to floor. Such are most of the department stores, and many other retail and wholesale establishments, and they are properly termed "conflagration breeders."

Imagine a department store crowded from basement to sixth floor with an open stock of inflammable merchandise. Allow a fire to start therein, perhaps at a light-well in the center of a large area floor, and at a distance from the street, whence the fire department streams will not penetrate. Unless extinguished at the very start, that building is doomed, and nothing but your reservoir upset upon it would avail. There will even be cause for thanksgiving if the fire does not extend to other parts of the city.

Certain barriers to the extension of fires do exist. Many fire departments are as efficient as they could well be made. They are a necessity and always will be, but experience has already shown their limitations. They are powerless with conflagrations, and in many cases a difference of one to five minutes in the time of their arrival determines whether or not the building and contents are a total loss.

The fact that a conflagration is not an annual occurrence in each city has caused the public to overlook the great waste caused by these spreading fires or to forget it shortly after having been singed. Yet yearly, millions upon millions of values are annihilated in buildings other than those in which the fires originate.

But a reforming influence is now appearing. This country's era of extravagance is passing. The merchant who in the past little thought what his insurance cost, and could be burned out and again resume business without great loss of trade, now scrutinizes every item of expense and dreads an interruption of business which will deflect his customers to competitors. Attention is therefore directed to a reduction of the fire cost in cities. "Fireproof" buildings, so called, have been erected, only to find that even the best types are not fireproof so long as they contain combustible contents,

or are exposed by combustible buildings and inflammable stocks. Furthermore, it would be impracticable, within our day and generation, to tear down a city and replace it with these so-called "fireproof" structures. Neither can we do away with their combustible contents. So we would be quite at a loss were it not for another factor which is on the increase each year, namely, *The Automatic Sprinkler System.*

This type of protection has been developed during the last twenty years. It was first applied to mills and workshops, and almost all such properties of prominence are now so protected. These are mostly isolated risks and alone receive the benefits of such protection; but when a system is installed in a city, every property in the conflagration district profits.

Yet the reverse is true, and a sprinklered city risk is still quite insecure so long as exposed by unsprinklered neighbors, for the exposure in burning will likely open the sprinklers on all floors of the equipped building, thus overtaxing any water supplies and pipe sizes which it is feasible to provide. Yet such an equipment has already in several instances — notably the Brown-Durrell fire in this city — retarded a spreading fire sufficiently to prevent a conflagration, although the building itself suffered practically a total destruction.

It is not my intention here to advocate the automatic protection of individual city risks, which is already a well-established custom, but to point out the great saving in fire cost, and the feasibility of the automatic sprinkler protection of *all* the buildings in the congested districts of cities; in other words, the practical *elimination of the conflagration hazard.* It is possible that underwriters may be able to hasten this work by allowing a special rate reduction upon a block when all the buildings therein are sprinklered.

Automatic sprinklers afford the chief means of private fire protection, and possess a prompt penetrating power not obtainable by any other known means. They act *instantly*, long before any alarm could be given at the public fire box; *locally* at the seat of fire, not being blinded by smoke into discharging large quantities of water where it is not needed; and *forcibly* when properly installed and fed by water under heavy pressure, filling the space with an irresistible deluge which not only quells the fire, but blankets the smoke, which would otherwise drift through the building, accomplishing an uncertain damage, impeding the exit of the inmates, and the subsequent

duties of watchman or fireman. This cannot be done by hose-stream service, and it is time the fact was realized. Of late, it has been emphasized almost weekly by the fires in Philadelphia and Newark.

Already property owners in large numbers have installed sprinklers. Their buildings are dotted here and there all over the city maps. What is needed now is the filling in of the intermediate spaces. Shortly the community will call for it. If three fourths of the buildings in a block are equipped, the portion not protected will be considered as a public menace, and public statutes may properly compel its equipment. Already they dictate as to the storage of oils and other extra inflammable substances, regulate construction, and compel the maintenance of standpipes, hose, fire escapes, etc. Doubtless, the landlord will in time consider the sprinkler system just as necessary a part of his fittings as the heating or lighting systems, and the municipality will have a corps of inspectors to see that the protection is not impaired.

Now all this means many, many more connections from the water-works systems, which is where your interests and those of the Fire Protection Engineer come together. This "coming together" should be a happy union of effort, not a collision, and I surely voice the wish of my associates in indicating our desire so to make it. Surely a great responsibility rests upon the water department in providing and maintaining an adequate service.

The public looks to the underwriter for the sprinkler specifications, and the latter looks to the city water-works system as, in most cases, the best possible source of water supply.

Very properly it is your duty to be informed as to the use of the connection, to avoid undesirable features, and, all being satisfactory, to provide the supply for the fire equipment. In past years there has been much abuse in the use of a water-works connection. But times have changed. The day of lax specifications and inspection is passing. We must rely to a considerable extent upon the service received from the water-works system, making much dependence upon private water supplies only when the public system lacks in pressure, volume, or quality.

As to quality, we have little to fear in New England, but in some other parts of the country, mud, eels, etc., are very serious obstructions to the smaller sprinkler pipes and to the sprinkler heads themselves. Neither is the lack of volume so much to be feared in the central city districts, but the pressure is often found wanting. This is partly

due to the increasing height of buildings. It is a fact, often overlooked, that sprinklers need a high pressure maintained upon such heads as may have opened in order to accomplish that which is expected of them. Seventy-five pounds is ideal, and the pressure is considered inadequate if less than twenty-five pounds at the sprinklers in the upper story.

Naturally, we have to take the public pressure as we find it, and when it is deficient, there are three types of private water supply commonly specified,—pressure tanks, pumps, and connecting pipes for attachment from the public fire engines. The pressure tanks are very simple; nothing more than boiler shells located upon the upper floor or roof, filled two thirds with water and the remainder with air compressed at seventy-five to one hundred pounds, which will expel all the water, the last leaving the tank at fifteen to twenty-five pounds pressure.

As these tanks can be filled with water from the public system, cleaned out and inspected as frequently as you like, you could have no objection to their connection to a sprinkler system which was also fed by the public water works. You object to a similar connection from a pump, draughting from some uncertain and perhaps foul source of supply which may, by the leakage of the check valve in the street connection, discharge its contents back into the street main, thus polluting the public water supply. We must admit the argument at once, and should be able to furnish a cement-lined reservoir or wooden tank, filled by city water, and cleaned out periodically, from which the pump shall draught.

In the past, varying insurance regulations governing automatic sprinkler equipments were issued, but in 1896 the National Fire Protection Association, composed of the various boards and bureaus in this country and Canada, formulated uniform regulations governing the installation of automatic sprinklers, which are now in general use throughout the land. They are presented as an appendix to this paper.

The rule that a sprinkler orifice shall be designed to discharge approximately twelve gallons per minute under five pounds pressure is the basis upon which the entire regulations are framed. This means a discharge under higher pressures approximately as follows: 10 pounds, 17½ gallons; 15 pounds, 21½ gallons; 20 pounds, 25 gallons; 30 pounds, 30 gallons; 40 pounds, 35 gallons; 50 pounds, 40 gallons; 75 pounds, 50 gallons; 100 pounds, 58 gallons.

As the equipments are, under average conditions, expected to allow the opening of, and proper supply of water to, at least forty sprinklers in any one fire, you will see that a considerable consumption of water may result. A system installed under these rules never fails except when the water for such a discharge is not forthcoming, due to weak water supplies, closed valves, or obstructed pipes; or when too great a number of heads is opened, due to quick-spreading fires as a result of explosive or highly inflammable contents, draughts from vertical openings, blower systems, etc., or when the contents are piled so as to prevent a proper water discharge. The better supplied systems can discharge under sufficient pressure for efficient spray service at least a thousand gallons per minute, the equivalent of four standard hose streams.

These national regulations do away with individual fads and fancies, and place before you and the property owners in black and white just what is, and is not, desired.

We have alluded to the sprinkler orifice, quantities of water discharged per minute, the desire for a water-works connection, and the use of pressure tanks, pumps, and steamer connections. The rules are ample and would serve as the text for a very long sermon, but I will allude to but one more point which may be of special interest to you.

We intend to prohibit the use of sprinkler piping for anything but fire service. Circulation in same means the presence of objectionable sediment. Let the interior hose and domestic pipes be on a separate metered connection.

The use of a proper alarm valve on each sprinkler system will be a positive check upon any circulation. Such a valve will eventually be considered a necessary part of every system.

It has been my purpose to-day to call your attention to the extensive use of automatic sprinkler systems, and the probability of their still more general adoption in the future; to state our appreciation of the great value in a water-works connection and our intention to have it properly used; and finally to indicate the uniform rules now in force governing this subject, which can be referred to in detail to fully understand this method of applying water upon fires, a method which must be chiefly relied upon for the prevention of serious city conflagrations.

The general principle underlying automatic sprinkler protection is well understood and appreciated by firemen and all who have made a

general study of extinguishing fires; namely, the application of water directly to the fire in its first or incipient stage. Automatic sprinklers properly installed are in every closet, under every stairs, in the center of all large stores as well as front and rear, in every portion of the building, ready night and day without the intervention of human agencies to distribute the water directly on the fire and in its early stages when it can be controlled. The great value of water-works connections in supplying water to sprinkler systems is understood and appreciated, and we need your assistance and advice in our efforts to bring into more general use the application of this most important and necessary means of protection against conflagration hazards in the congested districts of our large cities and towns.

I beg to express my appreciation of the honor conferred in the invitation to address you at this time and on this subject. I hope it may be the commencement of mutual conference and mutual assistance between your valuable organization and underwriting associations.

APPENDIX.

Abstract of Automatic Sprinkler Regulations.

A. PRELIMINARY INFORMATION.

1. Many buildings require preparation for sprinkler equipment. All needless ceiling sheathing, hollow siding, tops of high shelving, needless partitions or decks should be removed. Necessary "stops" to check draught, necessary new partitions, closets, decks, etc., should be put in place that the equipment may conform to same.
2. Full effective action of sprinklers requires about 24 inches wholly clear space below roofs or ceilings; this loss of storage capacity should be realized in advance of equipment.
3. Sprinkler equipments require accessory woodwork, dry-pipe valve closets, ladders, anti-freezing boxing for tank pipes, etc. This work should be promptly attended if not let with sprinkler contract.
4. Sprinkler installation is a trade in itself. Insurance inspectors cannot successfully act as working superintendents nor correct errors of beginners. It is strongly recommended to entrust sprinkler work to none but fully experienced and responsible parties.
5. Experience teaches that sprinklers are ofttimes necessary where seemingly least needed. Their protection is required not alone where a fire may begin but also wherever any fire might extend, including wet or damp locations.
6. A maximum protection must not be expected where sprinklers are at more or less permanent disadvantage, as in the case of stocks very susceptible to smoke and water damage, buildings having deep piles of hollow goods, excessive draughts, explosion hazards, or large amounts of benzine or similar fluid.
7. Paper or similar light inflammable ceiling sheathing is objectionable and unnecessary. Where floors leak dirt, an acceptable sheathing may be made of lath and plaster, matched boards or joined metal. All channels back of sheathing to be thoroughly closed between timbers or joists. Sheathing to be tightly put together and kept in repair. In mill bays, sheathing to follow contour of timbers without concealed space.
8. Vertical draughts through buildings are detrimental to the proper action of sprinklers, and must be "stopped" where practicable.
9. Sprinklers cannot be expected to keep out fire originating in unsprinkled territory. Stringent measures should be used to cut off all unsprinkled portions of buildings or exposures.

B. THE AUTOMATIC SPRINKLER.

These rules (Sec. B) are but a partial outline of requirements. An automatic sprinkler which will meet these requirements and no more will by no means be necessarily acceptable.

1. As a basis for these rules, it is required that each automatic sprinkler have an unobstructed outlet of such size and form that with 5 pounds pressure maintained at the sprinkler, it will discharge approximately 12 gallons per minute.

2. An automatic sprinkler upon original test must not leak under a pressure of 300 pounds hydraulic pressure.

3. Sprinklers upon original test must not burst or leak by suddenly increasing the pressure from 0 to 300 pounds, repeated 500 or more times.

4. An automatic sprinkler when intended for ordinary use must, when immersed in hot fluid, fuse at not less than 155 degrees F. nor more than 165 degrees F. Head not to be under pressure in this test. "Hard heads" in like manner must fuse at not less than 275 degrees or more than 300 degrees F. The fusing point of solder should not change with age.

5. On original test an automatic sprinkler on fusing must open without perceptible halt or hesitation at any point of the opening action, all freed parts must throw clear. This test to be made without subjecting the sprinkler to pressure or depending upon the action of a coil spring.

6. An automatic sprinkler must be designed to open and spray satisfactorily in an upright or pendent position.

7. Rules for Distribution of Water from Sprinklers.

Sprinkler upright or pendent, with deflector 4 or 6 inches below smooth ceiling and 10 feet above smooth floor, —

Shall, under 5 pounds nozzle pressure, wet ceiling over an area of not less than 3 to 4 feet in diameter.

Shall, when under 5 pounds nozzle pressure, throw approximately 90 per cent. of water inside an area 10 feet square on floor.

Shall, when under 50 pounds pressure, throw not less than 75 per cent. of water inside the 10 feet square area.

Distribution in both above tests to be approximately uniform over the 10 feet square area.

Water should not be cut up into fine spray.

Rotary deflectors are allowable, but the distribution must be satisfactory with deflector fixed.

The distribution in any direction shall not be obstructed by yoke, levers, or other parts of sprinkler.

8. Automatic sprinklers must contain no iron, steel, or fibrous material subject to the effect of corrosion.

C. LOCATION AND ARRANGEMENT OF AUTOMATIC SPRINKLERS.

1. Sprinklers to be located in an upright position. (*Note.* — Where construction or occupancy of a room makes it preferable, permission may be given, except on dry pipe systems, to locate sprinklers in a pendent position.)

2. Sprinkler deflectors to be parallel to ceilings, roofs, or the incline of stairs, except that the deflectors of sprinklers in the peak of a pitch roof shall be horizontal.

3. Distance of deflectors from ceilings or bottom of joists to be not less than 3 inches nor more than 10 inches.

4. Sprinklers to be placed throughout premises including basements and lofts, under stairs and inside elevator wells, belt, cable, pipe, gear, and pulley boxes, inside small enclosures such as drying and heating boxes, tenter and dry room enclosures, chutes, conveyor trunks and all cupboards and closets except they have tops entirely open and so located that sprinklers can properly spray therein. Sprinklers not to be omitted in any room because it is damp or wet.

Special instructions must be obtained relative to placing sprinklers inside boxed machines, metal air ducts, ventilators and concealed spaces, and under large shelves, benches, tables, overhead storage racks, platforms and similar watersheds.

5. In vertical shafts having inflammable sides, a sprinkler to be provided for each 200 square feet of the inflammable surface.

Metal lined shafts are construed as inflammable.

Such sprinklers to be installed at each floor when practicable and always when shaft is trapped.

D. SPACING OF AUTOMATIC SPRINKLERS.

(Also see F, 4.)

1. The distance from wall or partition must not exceed one half the distance between sprinklers in the same direction.

2. A line of sprinklers should be run on each side of a partition. Cutting holes through a partition to allow sprinklers on one side thereof to distribute water to the other side is not effectual. This rule applies to solid or slatted partitions.

3. Under mill ceiling (smooth solid plank and timber construction, 6 to 12 feet bays) one line of sprinklers should be placed in center of each bay and distance between the sprinklers on each line not to exceed the following:—

8 feet in 12 feet bays (measuring center to center of timbers).
9 feet in 11 feet bays (measuring center to center of timbers).
10 feet in 6 to 10 feet bays (measuring center to center of timbers).

4. Under joist ceiling, open finished, distance between sprinklers not to exceed 8 feet at right angles with joists or 10 feet parallel with joists. (*Exception.*—An exception may be made to this rule *if the conditions warrant*, namely, *special permission* may be given to install but one line of sprinklers in bays 10 to 11¼ feet wide from center to center of the timbers which support the joists. In all cases where such bays are over 11¼ feet wide, two or more lines of sprinklers must be installed *in each bay* as required by the rules for spacing. This does not apply where beams are flush with the joists, in which case sprinklers may be spaced as called for in rule D, 4.

5. Under a pitch roof sloping more steeply than 1 foot in 4, one line of sprinklers to be located in peak of roof, and sprinklers on either side to be spaced according to above requirements. Distance between sprinklers to be measured on a line parallel with roof.

6. Under open finish, joisted construction floors, decks, and roofs, the sprinklers shall be "staggered" spaced so that heads will be opposite a point halfway between sprinklers on adjacent lines, the end heads on alternate lines to be within 3 feet from sides of room. (*Note.*—This regulation applies to all sprinklers under open finished joists not excepting the sprinklers within a bay whether on one, two, or more lines; where the joists are flush with timbers; or where the channel ways between joists are "stopped" at intervals. Care must be taken that the end and intermediate sprinklers do not violate the rules for joist work spacing.)

7. Special instructions must be received relative to location of sprinklers under floors and roofs of unusual construction which would interfere with distribution of water and for which provision is not hereinbefore made.

E. PIPE SIZES FOR AUTOMATIC SPRINKLERS.

1. In no case shall the number of sprinklers on a given size pipe exceed the following:

Size of Pipe.	Maximum No. of Sprinklers Allowed.
¾-inch,	1 sprinkler.
1 "	2 sprinklers.
1¼ "	4 "
1½ "	8 "
2 "	16 "
2½ "	28 "
3 "	48 "
3½ "	78 "
4 "	110 "
5 "	150 "
6 "	200 "

2. If more than 6 sprinklers be placed on a "branch line" of pipe, the following schedule shall apply:—

Size of Pipe.	Maximum No. of Sprinklers Allowed.
¾-inch,	1 sprinkler.
1 "	2 sprinklers.
1¼ "	4 "
1½ "	6 "
2 "	8 "
2½ "	16 "
3 "	28 "

Furthermore, no feeder to any such "branch line" shall be smaller than said "branch line." (*Note.*—The old-fashioned "Parmelee" or "tree" arrangement of piping, namely, a pipe with short branches to one sprinkler on either side, shall be construed as coming under this rule.)

F. FEED MAINS AND RISERS.

1. "Center central" or "side central" feed to sprinklers is recommended. The former preferred, especially where there are over 6 sprinklers on a branch line. End feed is not approved.

2. There should be a separate riser in each building and in each section of a building divided by fire walls. The size of each riser to be sufficient to supply all the sprinklers on any one floor, as determined by the standard schedule of pipe sizes. If the conditions warrant, special permission will be granted allowing the sprinklers in a fire section of small area (total number of sprinklers not to exceed 48 per floor) to be fed from the riser in another section.

3. Where there are sprinklers enough in one room to require a 6-inch riser, according to schedule, it is preferable to have these sprinklers supplied through two or more smaller risers.

4. Where two or more floors communicate by openings not provided with approved "stops," acceptable "curtain boards" must be fitted around the openings at each floor; or, by consent of Board having jurisdiction, the automatic sprinklers at each floor may be placed within one foot of the openings.

(Sketches of piping plans omitted.)

G. VALVES AND FITTINGS.

1. Pipes must be supported in a substantial manner by wrought or cast iron hangers well secured.

2. Long bend fittings are recommended.

3. On wet systems, there shall be a test pipe ¼ inch in diameter connected directly with each riser in upper story and arranged to discharge outside building.

4. There shall be a straightway gate valve and a straightway check valve in the pipe connecting each water supply with sprinkler system. Straightway check valves to be placed in horizontal pipe, or in vertical pipe "looking up," never "looking down."

5. All gate valves (except they are fitted with post indicators) in supply pipes to sprinklers, in discharge pipes from tanks, in suction and discharge pipes from pumps, to be of outside screw and yoke or approved sign indicator pattern, and to be kept secured open with padlocked or riveted leather straps passing around the riser and spoke of the wheel. Draw-off valves to be secured closed. Cases about post gate valves to be arranged to drain through at least a ¾-inch outlet having a non-corrosive bushing.

6. Drip pipes to be provided to drain all parts of system. Drip pipes at main risers to be not smaller than 2 inches.

7. Main discharge pipes from gravity and pressure tanks, as well as from water-works systems and pumps, to connect with sprinkler system at foot of riser. Locate in this lower level the check valve in each connecting pipe, also one gate valve controlling all water supply to sprinklers. Place the gate valve called for in each connecting pipe close to the supply, as at the tank, pump, or in connecting pipe to riser from water-works system.

8. Where sprinklers are supplied from yard main, if possible, place an outside post indicator gate valve in connecting pipe at safe distance from building (say 40 feet).

9. When a pump, not located in a non-combustible pump house, discharges into a yard main fed by another supply, a check valve or post gate valve shall be placed in this discharge pipe outside the building underground.

10. Each underground check valve to be located in a pit accessible through manhole. Pit to be tight enough to keep out water from the ground or surface, and to be provided with a deck forming a double air space, to prevent freezing.

11. A standard make, 5-inch dial, spring pressure gage to be connected with the discharge pipe from each water supply (this includes the connecting pipe from public water works); also with each sprinkler system above the alarm check or dry valve; also at air pump supplying pressure tank, at pressure tank, and in each independent pipe from air supply to dry systems. Gages to be located in a suitable place, and where water will not freeze. Each to be controlled by a cock valve having a square head for wrench. A plugged tee or pet cock to be located between each cock and gage.

H. ALARM VALVE SYSTEM.

1. Every automatic sprinkler system should contain an alarm valve so constructed that a flow of water through same would operate an electric gong, a mechanical gong, or both, as the character of the property and circumstances may require. In cities where there is a thermostat alarm company with a central station, the alarm valve may be connected with such central station. In other places, especially in small towns, the valve may be directly connected with public fire department house or some other suitable place.

The use of both electric and mechanical gongs is strongly recommended. The gong of the latter can be located on the outside of building or any other desirable place on the premises. Valve should be so constructed that the flow of water through but one sprinkler would cause it to operate. It must not be affected by the varying water pressures received from street mains or automatic pumps. It must have a water way equal to or greater than the pipe in which it is installed and must be so designed as to but little diminish the flow of water. Valve to be so located that the passing of water through any of the sources of supply to any of the sprinklers will cause its action. To accomplish this in some equipments, it would be necessary to use two or more alarm valves. Construction of valve to be such that it cannot be prevented from opening in full by water column, corrosion, sticking of parts, or sediment. No valve to be installed unless it has the approval of the underwriters having jurisdiction.

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J. WATER SUPPLIES.

1. *Double Supply.*—Two independent water supplies are absolutely essential for the best equipment. At least one of the supplies to be automatic and one to be capable of furnishing water under heavy pressure. The following are acceptable supplies: Public

water-works system, duplex steam pump, private reservoir or standpipe, gravity tank, air pressure tank, rotary pump. The choice of water supplies for each equipment to be determined by the underwriters having jurisdiction.

2. No water supply for sprinklers to pass through a meter or pressure regulating valve, except by special consent.

3. Connection from water supply or main pipe system to sprinkler riser to be equal to or larger in size than the riser, and to supply no hydrant or standpipe.

K. PUBLIC WATER-WORKS SYSTEM.

(Rules also applicable to private reservoir and standpipe systems.)

1. Should give not less than 25 pounds static pressure at all hours of the day at highest line of sprinklers.

2. Street main should be of ample size, in no case smaller than 6 inches.

3. If possible, avoid a dead end in street main by arranging main to be fed at both ends.

L. STEAM PUMP.

1. Steam pump to be of approved duplex type (underwriters' pattern preferred), of the capacity named by the underwriters in each instance, but never less than 500 gallons rated capacity per minute, so located on the premises as to be free from damage by fire or other causes, and to take water from an approved source having a sufficient quantity of water to supply the pump while delivering its rated capacity for at least sixty minutes. Suction pipe to have a strainer, and, if the lift be more than 5 feet, a foot valve may be recommended. If pump is to be a supply for hose or open sprinklers, as well as automatic sprinkler system, it should never be of less than 750 gallons rated capacity. (*Note 1.* — In determining the rated capacity of a pump, 70 revolutions shall be allowed for 12-inch stroke, 75 revolutions for 10-inch stroke. Ten per cent. shall be deducted for slip.) (*Note 2.* — It is requested that a clean and well-floored room with a tight roof be provided for fire pump. No room is acceptable where the conditions prevent or discourage the engineer from keeping pump in good condition.)

2. Where a pump does not take water under a head, it should be primed from water tank, used exclusively for that purpose, of not less than 200 gallons capacity or its equivalent. Priming pipe to connect into each of the four water chambers.

3. Pump to be so located in respect to its water supply that at no time shall it have a lift of over 15 feet during sixty minutes discharge at rated capacity. (*Note.* — When a pump takes water under head, there shall be a gate valve in suction pipe, located at pump.)

4. Discharge pipe to contain a spring relief valve and pressure gage.

5. Two and one-half inch hose connections with gate valves to be placed in pump discharge, at pump (one connection for every 250 gallons rated capacity of pump). These are required for the purpose of properly testing pump.

6. If an automatic regulator is placed in steam connection to pump, it shall be on a by-pass with a shut-off valve on each side of same and a satisfactory steam trap provided.

7. Steam pressure of not less than 50 pounds to be maintained at all times. Provision to be made for sufficient steam power to run pump to full rated capacity; not less than 40 horse-power for each 250 gallons rated capacity of pump. Means shall be provided for liberally oiling steam chests of pumps independent of sight feed, namely, hand oil pump. Three gallons special quality oil to be kept at pump for this purpose.

8. Where a steam pump is the primary supply an automatic gage to record the steam pressure in pump steam chest shall be applied.

9. Fire pump to be operated at least once a week.

10. Any boiler house on which pump depends for steam supply should be of brick or stone, detached or cut off from main buildings by standard fire doors.

11. Steam pipe from boiler or boilers to pump to supply pump only; as far as practicable to be located where not subject to injury in case of fire or other accident, to be fitted with steam trap and drip pipe. Where there is more than one boiler, the arrangement of pipes and valves to be such that each boiler may be "cut out" without interrupting steam supply to pump from the other boilers. Where there are several fire pumps, each should be arranged to be "cut out" without affecting the others. Pump exhaust to be free from liability to back pressure.

12. Valves to be located in boiler house so that all steam supply to other buildings may be cut off from them in time of fire and reserved for pump.

M. GRAVITY TANK.

1. Elevation of bottom of tank above highest line of sprinklers on system which it supplies and capacity of tank to be specified by the underwriters having jurisdiction. In no case shall a tank of less than 5 000 gallons capacity be accepted. The greater the elevation of a gravity tank, the less likelihood of inefficient service. Underwriters having jurisdiction are urged to have such tanks placed at the greatest practicable elevation.

2. Water for filling tank shall be conveyed through fixed iron piping not less than 1¼ inches in size. Sprinkler piping not to be used for this purpose.

8. Tank to be used as a supply to automatic sprinkler system only, except that, at the discretion of the underwriters, tank may be made larger than called for, and so arranged that the excess supply only may be used for domestic service.

4. *Tell-tale.*—All gravity tanks to be provided with a water level indicating device satisfactory to the underwriters having jurisdiction.

5. End of sprinkler riser should enter bottom of tank and project above bottom 4 inches, to avoid sediment entering pipe system.

6. Provision shall be made to drain each tank independent of the sprinkler system.

7. Provision must be made to prevent water from freezing in tank and pipes communicating with the same. A tank exposed to the weather must have a double cover, provided with trap door. When a steam pipe is used for heating tank, it should be run directly from boilers with controlling valve located in boiler room. A check valve to be located in this pipe at tank to prevent siphoning.

8. A permanent substantial ladder extending 3 feet above tank or satisfactory stairway must be maintained to allow access to tank on outside. Also a ladder to be permanently located inside tank. (*Note.*—The outside ladder at a tank exposed to the weather affords a treacherous foothold at best. For years after it is erected, it must be used by inspectors in all seasons and conditions of wind, temperature, and storm. A ladder of much more than ordinary strength and durability is required and must be most securely attached. A heavy iron pipe ladder, having diamond-shaped treads, is recommended.)

9. Tank to be built and supported under specifications and supervision of the municipal or building authorities.

N. PRESSURE TANK.

1. Total capacity of tank or tanks to be not less than 4 500 gallons except by special consent.

2. Tank not to be located below upper story of building. The two valves in water gage are ordinarily to be kept closed, and opened only to ascertain the amount of water in tank; as breaking of or leakage about glass would cause the escape of pressure.

3. Water for supplying tank to be conveyed through fixed iron piping not less than 1¼ inches in size. Sprinkler piping not to be used for this purpose. Pipe from air pump to tank to be not smaller than ¾ inch; to be independent of water supply pipe; to connect with tank above the water level. Both water and air connections to be fitted with check and stop valves located near tank.

4. Tank to be kept two thirds full of water, and an air pressure (not less than 75 pounds) maintained, such as will give not less than 15 pounds' pressure on highest line of sprinklers when all water has been discharged from tank.

5. Wherever steam is available, a steam-driven air compressor shall be used.

6. Tank to be used as a supply to *automatic* sprinklers and hand hose only. (See Rules 8, 1 and 2.)

7. Provision shall be made to drain each tank independent of the sprinkler system.

8. It is desirable to have water fed to tank by a pump so that proper water level may be restored at any time without reducing air pressure.

9. Tank to be built and supported under specifications and supervision of the municipal or building authorities.

O. ROTARY PUMP.

1. To be of approved type, rated capacity never less than 500 gallons per minute; to have gears at both ends. To be located where easy of excess and free as possible from damage by fire. If inside main building, to be arranged, together with water wheel, to start from outside of building; to take water from a source having sufficient quantity of water to supply the rated capacity of the pump for sixty minutes.

2. In many cases it will be found necessary to provide an approved friction clutch by which shafting and machinery can be disconnected and full power confined to driving pump.

3. Pump to be so located in respect to its water supply that at no time shall it have a lift of over 10 feet during sixty minutes' discharge at rated capacity. To have hose connections, spring relief valve, gate in suction and pressure gage the same as steam pump. To be started by friction clutch or friction gearing. Care should be taken to provide sufficient power to run pump to full rated capacity.

4. Rust and usage will impair the efficiency of a rotary pump more quickly and to a much greater degree than an underwriter steam pump. In most cases, a rotary pump cannot be as advantageously located and is under less control. Consequently, it is not to be recommended when practicable to install a steam pump.

5. Means should be provided for liberally oiling journals. One barrel special quality oil to be kept at pump for this purpose.

P. STEAMER CONNECTION.

1. In addition to the above required double supply, it is recommended that a hose inlet pipe to sprinkler system be provided for connection from hose or steamer of public fire department, in all cases where the public water works is not sufficient to exert 25 pounds' pressure at highest sprinkler, or is not connected to the sprinklers.

Said pipe to be not less than 3 inches in size and fitted with a straightway check valve, but not with a gate valve. To be attached *above* dry valve or gate valve controlling sprinkler riser where there is but one riser and *below* said dry or gate valves where the equipment has more than one riser.

Hose connection to suit thread of public department.

Large buildings to have several connections designated by proper signs.

Q. UNDERGROUND PIPES AND FITTINGS.

Hydrant Mains.

1. No 4-inch pipe to be used.

2. For pipes extending to a dead end—

(*a*) Allow 200 feet 6-inch pipe with one 3-way hydrant.

(*b*) Allow 500 feet 6-inch pipe with one 2-way hydrant. (This might be extended in special cases.)

(*c*) Allow 1 000 feet 8-inch pipe with one 3-way hydrant.

(*d*) Allow 500 feet 8-inch pipe with one 4-way hydrant or its equivalent in hose streams.

(*e*) Allow 300 feet 8-inch pipe to first hydrant, where there is a hydrant equivalent of six streams.

(*f*) Whereas the above limitations for 8-inch pipe are low, it is deemed undesirable to have over four streams on a dead end, and loop system would ordinarily be employed where it is intended to concentrate over four streams at one point.

(*g*) Never allow more than four streams on 6-inch branch pipe.

3. For loop systems—

(*a*) With two 3-way hydrants, say 250 feet apart, allow 250 feet 6-inch pipe from each hydrant towards source (preferably use 8-inch pipe with 3-way hydrant systems).

(*b*) With two 2-way hydrants, say 250 feet apart, allow 500 feet 6-inch pipe from each hydrant towards source.

(*c*) With three 2-way hydrants 250 feet apart allow 250 feet 6-inch pipe from end hydrants towards source.

(*d*) To feed four 2-way hydrants or their equivalent, use 8-inch main feed pipes and allow 500 feet of 8-inch pipe each way from end hydrant to water supply, rest of pipe 6-inch, if desired.

(*e*) To feed five 2-way hydrants or their equivalent, use 8-inch main feed and allow 250 feet from end hydrants to water supply.

(*f*) Where water supplies are such that over four streams can be obtained, loop pipes should never be less than 8-inch.

(*g*) In laying out a loop system where it is intended to concentrate four to six streams at any one point, an 8-inch loop should be amply sufficient even if it is as much as 1 000 feet from supply to point of concentration.

(*h*) Under conditions where a large number of streams can be concentrated at one point, it would be sometimes desirable to use 10-inch or 12-inch pipe.

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S. MISCELLANEOUS RULES.

1. Circulation of water in sprinkler pipes is very objectional owing to greatly increased corrosion, deposit of sediment, and condensation drip from pipes; sprinkler pipes must not be used in any way for domestic service.

2. Hand hose to be used for fire purposes only may be attached to sprinkler pipes within a room under the following restrictions: Hose not to be larger than 1¼ inches. Nozzle not to be larger than ½ inch. Hose not to be connected to any sprinkler pipe smaller than 2½ inches, never to be attached to a dry pipe system.

T. CAUTIONS AND PROHIBITIONS.

1. Where pipes are painted or bronzed for appearance, the moving parts of sprinkler heads must not be so coated.

2. Sprinkler heads must be free to form an unbroken spray blanket for at least 2 feet under the ceiling from sprinkler to sprinkler and to sides of room. Any stock piles, racks, or other obstructions interfering with the foregoing are not permissible.

3. Where a building settles and deprives a dry pipe system of its drainage, the ends of lines must not be raised to violate Rule C, 3. The drainage should be restored by shortening the vertical piping.

4. Use of water or circulation of water above base of sprinkler riser is prohibited. (See Rules S, 1; M, 2; N, 3.)

5. Notice that it is the deflector of a sprinkler which must be at least 3 inches (and not over 10 inches) from ceiling or bottom of joists; 5 to 6 inches is the best distance with average pressure and present types of sprinklers. (See Rule C, 3.)

6. Sprinkler piping must not be used for the support of stock, clothing, etc.

7. It is not permitted to change, plug up, or remove the fittings pertaining to dry pipe valves, pressure tanks, pumps, gages, etc. If such fittings leak or become deranged, they are to be put in order.

8. There should be maintained on the premises a supply, never less than six, of extra sprinklers to promptly replace any fused by fire or in any way injured.

DISCUSSION.

PRESIDENT COOK.* Mr. Crosby's paper is now open for discussion. I may say, speaking from the standpoint of the water-works superintendent, that when we find a manufacturing concern is drawing water from the sprinkler system surreptitiously, it shakes our confidence in the sprinkler system and also in the man who is using it. My experience has been that the ordinary manufacturer, if he gets short of water, will go to the city supply. Now, what we want, and what Mr. Crosby suggests, is that we may be protected by the insurance people compelling every manufacturer to have nothing connected with the sprinkler pipes except the sprinklers themselves; and his suggestion of an automatic valve electrically connected, whereby in case of any draught through the check valve an alarm will be immediately rung, I think is a good one.

We must have some protection. Only this last week I went into a manufacturing establishment in my city and found that for ten days they had been using water through their fire supply to feed their boilers. Their pump supply from the river had got clogged up; but during the manipulation of the valves to feed their boilers through the heater the fireman got mixed up in some way, so they could n't supply the boilers at all, and had to shut the mill down. They telephoned to the water office and wanted to know if we had shut the water off; their consciences began to trouble them. I went over there and soon remedied the trouble. Now we have a meter on the fire pipe. If the insurance people will insist that no connection shall be made from the fire pipes except for sprinkler purposes, it will surely help us a great deal.

MR. EDWIN C. BROOKS.† I fully agree with Mr. Crosby as to the desirability of the adoption of some regulation in regard to the introduction of fire supplies that would meet the approval of both the insurance companies and the water-works authorities.

I find that plans are made for the introduction of a supply of water to fire pumps without the least regard to the city supply in case of accident, or failure of some one to do what was expected to be done in case of fire, or through the failure of some check valve to operate as was intended. The whole idea seems to be the protection of the property in question. An auxiliary supply for fire pumps is, no

* Superintendent, Woonsocket Water Works.
† Superintendent, Cambridge Water Works.

doubt, in many cases necessary, and I think no one should object to such an arrangement, provided, of course, that the supply is equal in purity and fitness for domestic use to that of the city, and is kept so.

MR. MORRIS KNOWLES.* There are two questions I would like very much to ask Mr. Crosby. One is, does he know of any place where this automatic electric alarm valve has been used, and with what success; the other is, after a new plant has been equipped for a fire service, thoroughly in accordance with the ideas of the underwriters, with no connection whatever except for fire sprinklers, have they any penalty which they inflict upon the insured if any connection shall be made afterwards, or do they do anything to prevent it? Do they have inspectors, for example, who go around and inspect all the piping, and who will prevent anything of that sort?

MR. CROSBY. Replying to the first question, Mr. President, there is an alarm valve now in service called the English alarm valve. It is the only one generally in use in New England, and has been employed for some seven or eight years, and with a very fair degree of success. I think I am safe in saying that from seventy-five to eighty-five per cent. of the equipments in the central business section in Boston are fitted with these alarm valves. They are connected electrically with the central station of the thermostat company, which is the automatic fire alarm company, and upon any movement of water in the pipe the valve must open, the electric connection is made, and it will ring an alarm at the central station, giving notice either of a fire or of leakage. The system has met with very excellent success in Boston, but of course it is under the best conditions here, there being this large central station where there are people who can within a couple of hours remedy any defect, and who test the circuits out every day.

There are a number of reasons for installing that valve. We find that the property owner, as a rule, is very anxious to put it in. He is covered under his fire policy for any damage which may result if a sprinkler opens in case of fire and discharges water through the building, damaging the stock on the lower floors; but in case he leaves a window open at night, forgetting to close it, and the water in a sprinkler freezes and bursts the head, allowing the water to run down through the building during the night, he has to stand the loss himself. Now, by having such a valve in he is not only doing

* Civil Engineer; Water Commissioner, Lawrence, Mass.

something which helps the insurance companies, for which he gets an allowance in the rate, but he is also protecting himself to a large degree against water damage due to a broken pipe or sprinkler.

Now, as to the second point, that of inspection. All of the sprinklered risks which get the sprinkler allowance are inspected from once in six weeks to once in three months by the insurance authorities. It is a part of the inspector's duty to find out if the system is being used for anything but fire purposes. We have found that when a circulation is maintained in the pipes they are being re-charged every minute or every hour with a new supply of water, bringing in its own percentage of sediment which will settle in the fittings, sprinkler heads and tees, resulting in clogging up the pipes, very much to the detriment of the interest of the insurance companies; so we are looking out for that. Where the alarm valve is in use they simply cannot maintain a circulation, because the alarm would be ringing all the time. And, as I said in my previous remarks, we should look to the general introduction of that alarm valve in the future as one of the best safeguards against using a sprinkler system for anything but fire purposes.

MR. KNOWLES. Is this alarm valve always closed?

MR. CROSBY. The alarm valve is always closed. The one to which I have referred is nothing more than a vertical check valve. The disc rests on a seat ring which is channeled, the channel being covered and closed by the disc when the disc is seated. Out of that annular seat ring is conducted a small pipe which connects with a diaphragm circuit-closer, or with a water rotary mechanical gong. The minute there is a flow of water in the pipes the disc rises, allowing the water to flow into the seat ring channel and a pressure to be established, by the water running out in the short length of pipe, and operating the electric circuit-closer or ringing the mechanical gong, as the case may be. We like very much to have both, because it makes two strings to the bow, one electrical and one mechanical, and with less chance of a failure.

MR. JOHN C. CHASE.* I would like to ask Mr. Crosby if these establishments he speaks of in and about Boston, which have been equipped in this way, are mercantile or manufacturing establishments?

MR. CROSBY. They are largely mercantile. Those to which I have been referring are almost altogether so, because it was my

* Civil Engineer, Derry, N. H.

intention in this paper simply to allude to congested districts in cities. It is a very great problem to the underwriters to-day, that of the congested districts, where there is a chance at any time that a fire may get beyond control in any one of the buildings and menace all the others in the district. Now, there is scarcely any manufacturing in a congested district, because the rents are too high for that purpose. The manufacturing risks, as a rule, which are equipped with sprinklers, are outlying, either semi-detached, around the outskirts of cities, or altogether detached in the suburbs and country.

I might add that the sprinkler system is a subject in which I have been very much interested, and it has been of late years extending to classes of property quite new to it. As I have said, it was originally developed for mill protection, and they used it in textile mills, for instance, putting it in the picker room only, and then in the card room, and gradually extending to the other less hazardous sections, until to-day it is generally regarded as not paying to leave out any part of the building as free from danger by fire, and that if a plant is to be equipped with sprinklers it is wise to put them in every part of the premises. The extension of the system to new classes includes hotels as one interesting group of property. The Poland Spring House down in Maine, at which you have all stopped, is equipped in all of its laundries, kitchens, servants' quarters, attics, hallways, and throughout the entire upper floor of the hotel with automatic sprinklers. Theater stages are very generally equipped with sprinklers to-day, while the auditorium proper has been excepted. And, as I say, it is going into mercantile buildings very generally; and I even know of one dwelling house which has an equipment throughout the basement kitchen, put in by the owner who knew of the value of sprinkler protection, without any idea of getting insurance reduction for the partial equipment, but simply for his own protection.

Mr. Chase. I think the idea of an electrical alarm is very excellent, and if the manufacturing establishments can be either forced or prevailed upon to adopt it, it will relieve many of the troubles that water-works superintendents have to contend with. I suppose others here have had the same experience as I have had, that it is the manufacturing establishments that hypothecate the most water. They have the greatest use for it, perhaps, and they have a much better chance of getting it without detection, owing to the various ramifications of the supply pipes for fire purposes, than the ordinary mercantile establishments have.

MR. JOHN A. GOULD.* I might make one suggestion in the line of inspection. The concern that I am with has its pipes painted different colors. We have four or five different kinds of pipes, and it is very easy for an inspector to tell whether a pipe is tapped illegitimately or not. We have gas pipes, boiler pipes, steam pipes, fresh-water pipes, and salt-water pipes, and every one is a different color.

MR. JULIUS C. GILBERT.† I am a thorough believer in sprinklers for fire protection. When one of the gentlemen here was speaking of what water-works superintendents had to contend with, it brought to my mind a little incident which happened about two years ago. I was called to a large factory which was supplied with sprinklers, because they could n't get any water through the pipe; we went down under the factory, and there we found a six-inch pipe frozen solid for about seventy-five or eighty feet, which had pulled apart about four inches. The windows had been left open in very cold weather. Well, while we were contemplating what was to be done a man came rushing down to us and said, "The insurance inspector is here; what shall we do?" And I said, "We 'll fool him." We talked it over a few minutes, and decided upon a little strategy; and we opened some valves which were not connected with the fire service at all, and we showed the inspector that we had a first-class pressure all around the factory, and after taking him all around through the whole establishment we sent him off happy, believing that everything was all right. Well, we felt pretty good over it, but of course we repaired that pipe as soon as possible, and thawed it out and had everything all right and the water on before we went to sleep that night. I want to say one thing in regard to these insurance inspectors. I know that there are lots of men sent out to inspect who don't seem to know anything more about a system of piping than a boy two years old, and if any one wants to play any tricks on them it is very easy to do it. I would suggest that they send out men who know their business, and in such a case as the one I have spoken of I think it is excusable to play a little trick.

MR. HORACE G. HOLDEN.‡ I would like to inquire of Mr. Crosby what he considers the best available hydrant pressure in a residential portion of the city, where the buildings are rarely over two stories in height?

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†Superintendent, Whitman Water Works.
‡Superintendent, Nashua Water Works.

MR. CROSBY. Of course any figure is purely arbitrary. I would say that seventy-five pounds pressure maintained at the hydrant is the ideal pressure for house service in outlying city districts. It means a pressure at which streams can be attached and handled by hand without difficulty, and it will provide a stream which is sufficient for buildings of that height, and even for buildings of quite a bit greater height.

As regards the insurance inspector, this gives me a chance to get back a little. I won't avail myself very much of the opportunity, however, but will say I am glad to find out it is n't the water-works department alone which is being imposed upon. That is a tale I have heard so often that I had almost come to believe that really we were asking for a great deal more than we ought to, and it was a shame to impose so upon the water-works department. Now, of course I am willing to admit that a great many insurance men whom you meet don't know anything at all about a water-works system, or a sprinkler system, or anything of that kind, although they may ask you questions along those lines and attempt to give you an impression that they know more or less; you can generally see that they know less. But the fire insurance business is a very large one, and divided into a number of specialties to-day. There is the broker who places the insurance for the property owner. He is nothing more than the agent of the property owner, and he is looking after his interests, trying to get him the best rate of insurance, the best companies, and the best form of policy. Now, the broker once in a while may ask you questions, and, in many cases, it will be evident he does not know much about the fire protection of buildings. You must not confuse him with inspectors from the insurance company. Again, there are local agents. Many of them to-day are very fully posted about matters of fire protection, while others don't know anything about it. Then there is the underwriter, who has the general policy of the company to look after, as regards losses and rates and forms of policy, and there is the adjuster of losses, who may not know anything at all about sprinklers, and yet at some time in his career he may come in contact with you.

Now, outside of these classes there is the engineering department, which is maintained in all parts of the country to-day, and which has inspectors in its employ who are supposed to know their business. Ten or fifteen years ago there was very much less known about fire protection engineering than there is to-day. The sprinkler system

has largely developed within that period. The thermo-electric fire alarm has entirely developed within that period, and many other types of fire extinguishing and fire notification apparatus. It is our endeavor to secure inspectors who know their business, and it is safe to say that we have a great many of them who do, and we don't wish to have any who do not. So I think when you come in contact with these men they will as a rule be able to meet you on your own ground, and that they will ask nothing of you that they ought not to, and I am sure that they will appreciate any service you may be able to render them.

MR. GILBERT. I would n't like to have the gentleman think that we are not all interested in these things, and I can assure him that whenever I have had an inspector come to me I have used him as a gentleman; and if I did n't think he knew all about the matter, I tried to show him about it and do everything I could for him. We know what the insurance people do for us, and we try to help them all we possibly can. But I thought it was all right to tell a good story.

MR. GEORGE F. CHACE.* In regard to the question Mr. Holden asked about this matter of hydrant pressure, there is just one point which may be of interest that I recall in my experience. Some years ago, for an experiment, we tested the conditions of the fire service around a certain mill. The buildings were approximately of the size already mentioned, not more than two or three stories, and with fifteen streams through $1\frac{1}{8}$-inch nozzles, which were entirely satisfactory to the inspector, who showed he was in every way a shrewd man and understood his business, the gage at the hydrant showed sixty-five pounds pressure.

MR. CROSBY. Will you allow me just one word more, Mr. President, about a matter which has occurred to me since this discussion first began? In inspecting sprinklered risks in the last six months we have found forty-three gate valves controlling water supplies to sprinklers entirely closed. In a majority of cases this occurred in well-managed plants, where the fact was a humiliation to the superintendent or the proprietor; and yet it had taken place right under their noses, where the valves were in charge of a well-paid engineer and master mechanic, and where the valves were in sight and were passed by responsible people perhaps many, many times during each day. Now if that occurs inside of buildings, in connection with

* Superintendent, Taunton Water Works.

valves in sight, important valves supervised by well-paid and intelligent men, what must be occurring underground, in the city streets, where valves are being shut and opened by subordinates, for the purpose of making extensions or repairs or taps to buildings?

One important matter in this connection came to my notice about a year ago in a very large city in New England, where the yard main service was fed by a twelve-inch connection from the public main in the street. An inspection, which happened to be thorough, revealed the fact that the water which was expected was not forthcoming, and eventually we found that the twelve-inch gate valve in the street main was closed. Further investigation with a very obliging superintendent of water works revealed the fact that an extension of the main down to a few dwelling-houses, made a week before, had caused the closing of that valve, and "Pat Mulcaney," or some one else, was supposed to have gone around there with a wrench and opened it, but he had forgotten so to do. When he was brought to task he said he had opened it, but he evidently had not, for the valve was closed. Now, I am rather curious to know what system of inspection is practical for these water-works valves, which must amount to many hundreds in a city of any size. Upon asking the question in various places I have found that almost always some arrangement for seeing that the valves were open had been made. Very often the man whose duty it is to look at the hydrants spring and fall, and see that they are in proper condition, is also supposed to look at the valves throughout the city streets; but upon further investigation I would find that the man had really not gone to these valves, as it would turn out, unless he had learned that they had been closed for some reason. I would like for my own information to know if there is anywhere a regular system of inspection and examination of valves by thoroughly responsible parties.

President Cook. The question that Mr. Crosby has raised has surely put the water people on the defensive. There is no doubt that the inspection of the street valves should be in charge of a competent person. I hardly think there is a superintendent here who has not at some time during his experience found one or more valves closed which should have been open. I know I have, and I am willing to admit it.

Mr. R. J. Thomas.* I would like to speak of a system of testing and inspecting gates that we have in Lowell. The city is divided

* Superintendent, Lowell Water Works.

into three districts, and we have two men for each district who go around and inspect every gate box and service box, and also examine every gate, — put a wrench on it and see whether it is open or closed, and operate the valve slightly so as to see if the stuffing box is tight. They also do the same with the service cocks, going over the territory as often as they can during the summer season, or probably from the first of April until January, if the weather is favorable. Any valves which are closed are readily found in that way. The men make a report every day of what they have done the day before, and we have a record of their work for every day they are out, what gates they have examined, what service boxes, and everything they have done on the street. In that way, with six men doing that work all summer, I think there is n't much danger of a gate being left closed unintentionally.

PURIFICATION OF SEWAGE BY BACTERIAL METHODS.

BY LEONARD P. KINNICUTT, D.SC., PROFESSOR OF CHEMISTRY, WORCESTER POLYTECHNIC INSTITUTE.

[*Read September 19, 1900.*]

The danger from pollution of a water supply by the refuse of communities, their habitations, streets, and factories, is a constant source of anxiety to the water-works engineer, and it is on this account that I have been asked to address you at this time as to the work that has been done during the past few years on sewage purification and disposal.

The earliest method of sewage disposal was to run the waste products of the community into the nearest river or stream. In a sparsely settled region this caused little complaint; but as the district became inhabited and the towns and villages upon the stream increased in size, it became apparent that this method, though removing the filth from one's own door, would endanger the health and comfort of a large part of the community. It was then that the question of sewage purification and disposal became the subject of scientific inquiry. Without going into any detail as to the early work done upon the subject, I will only state that it resulted in the general adoption of either sewage farming or chemical precipitation as the best means of destroying the obnoxious substances contained in sewage. Sewage farming was based on the idea that plant life was capable, of itself, of decomposing the complex organic matters contained in sewage, and that its capacity to do this work was almost without limit; consequently it was thought that sewage could be applied continuously to cultivated land, and, if vegetation was not drowned out, not only would perfect purification take place, but an immense profit could be derived from making use of the polluting substances for plant food. So firmly were these ideas, especially the manurial value of sewage, implanted in the English mind, that the most marvelous undertakings were planned, and to-day at Barking one sees a tunnel which was started to carry the sewage of London one hundred miles into the interior, with the idea that the tunnel

should be tapped at certain intervals and the sewage sold, at I know not what price per thousand gallons, to fertilize the land. This is hardly less startling than the idea of recovering the gold that is in sea water.

Treating sewage with chemicals was an attempt to remove not only suspended matter, but also the soluble decomposable substances, it being believed that certain chemicals like iron or aluminum sulphate had the property of uniting with the soluble organic substances, forming insoluble compounds, and that by using suitable chemicals all the polluting matter could be removed. It was also conceived that a profit might be made by this process in selling the precipitate formed as a fertilizer, and over two hundred different patents have been taken out for thus treating sewage.

To-day neither of these methods is considered as successfully accomplishing its object. Sewage farming has invariably ended in failure, except in those few cases where the land was of an exceptional character and of very large area compared with the population to be served, as one acre to fifty persons. Chemical precipitation only removes the suspended matter, all the soluble putrefying substances still remaining in the effluent; and this effluent is almost as obnoxious as crude sewage when run into a water course. Until 1890, however, these two methods were the only ones used on a practical scale. In that year the Massachusetts State Board of Health published their Report on the Purification of Sewage and Water, and showed by a series of careful experiments that under proper conditions all the decomposing and polluting substances in sewage could be destroyed by micro-organisms which are contained in the sewage and known under the name of bacteria; and all methods by which organic matter in sewage is destroyed by aid of bacteria, under conditions controlled by man, are now classed under the general term *biological or bacterial purification of sewage.*

Bacteria are a low form of vegetable organism which multiply by a process of transverse division. Though commonly considered as dangerous enemies, they are, in fact, our greatest friends, for it is only a comparatively few species, those that exist on living matter, that cause disease. The great majority obtain their nutritive material from dead animal and vegetable matter, and resolve these substances into simpler compounds, as carbon dioxide, water, ammonia, nitrates, — which are the food supply of higher vegetable life. Were it not for the presence of these bacteria, disposing, as they do, of

effete organic matter and changing it into plant food, human life on this earth would, seemingly, be impossible. These are the bacteria that are present by the hundreds in a cubic foot of air and in a cubic centimeter of so-called pure water, and by the millions in a cubic centimeter of polluted water, or of sewage.

Bacteriology as a science may be said to date from Pasteur's experiments on the causation of the putrefaction of beer and the souring of wine, in the middle of the present century; and it is only at a very recent date that there was any reliable knowledge as to the action of bacteria in the purification of sewage.

Fresh sewage contains, in immense numbers, the class of bacteria which live on dead organic matter and which cause its decomposition. These bacteria can be roughly divided into two great groups, each containing numerous species. These groups are called the anaërobic and the aërobic groups. The anaërobic group embraces all those species that live, grow, and multiply best out of contact with air and light; the aërobic, those species that live, grow, and multiply only in contact with air. Each group plays its own special part in the destruction of the effete matter contained in household waste. The anaërobic bacteria act first. They disintegrate the solid animal and vegetable matters, liquefy them, and bring them into solution. The aërobic bacteria act upon the disintegrated and liquefied compounds and, by a process of oxidation, change them into harmless gases.

For the destruction of dead organic matter both groups of bacteria are necessary; the anaërobic to disintegrate and liquefy the complex organic substances, the aërobic to change those simplified and liquefied compounds into harmless products.

Taking this as a brief outline of what takes place in the decomposition of excreted and effete matter, we are now in position to review the various methods classed under bacterial treatment of sewage.

As I have stated, the credit of showing that sewage can be successfully purified on a large scale by bacterial treatment belongs most certainly to the Massachusetts State Board of Health. Their experiments showed that all that was necessary to completely destroy dead organic matter was to provide conditions favorable to the action of bacteria. These conditions they believed were fulfilled by providing suitable material on which the micro-organisms could be retained, surrounding these micro-organisms at certain intervals with air, and providing periods during which they could rest. A suitable

material was sand, from four to five feet in depth, and the surrounding the bacteria with air at definite intervals, and allowing periods of rest, was accomplished by under-draining the sand and by allowing the sewage to flow on the sand only six hours out of each twenty-four. The combination of these conditions gave us the process known as Intermittent Filtration.

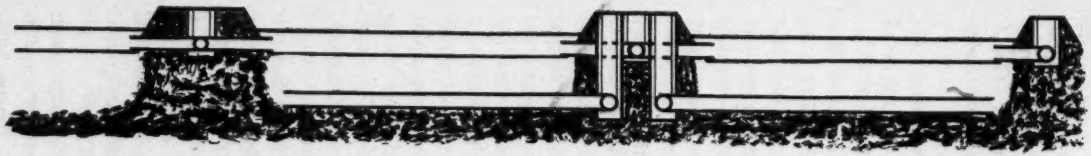
Fig. 1 gives a section and ground plan of four of the sixteen experimental intermittent filtration beds of the sewage plant at Worcester, Mass., and also a diagram showing the valves controlling the flow in the feed pipes and in the drains.

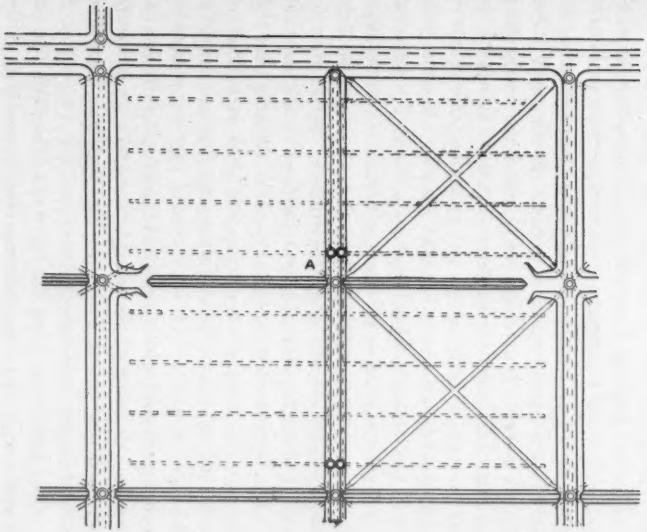
The beds are of coarse sand, from which all pockets of clay and quicksand have been removed. They are each of about one acre superficial area, and are divided from each other by dikes, those containing the feed and drain pipes being raised six feet above the level of the beds, while those running perpendicular to these are only eighteen inches high. In order that certain of these beds should be fairly water-tight, the dikes surrounding them are lined with tamped clay. The drains of Akron pipe, laid with open joints, are six feet below the surface of the bed, and are fifty feet apart, the outer ones being twenty-five feet from the edge of the bed; the first hundred feet of pipe in each bed is 10-inch pipe, the remainder is 8-inch. The drains connect with two 24-inch pipes, placed in the dikes between the beds, and by the aid of valves the drainage of each bed can be separately collected in order that the exact action of the bed can be tested.

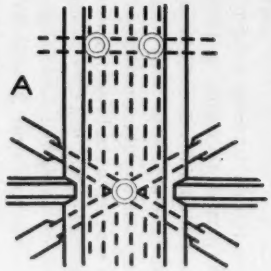
The feed pipes are eighteen inches in diameter and are connected with split pipes, which in four of the beds extend across the entire distance of the bed in order to give an even flow over the whole surface of the bed, and the flow upon the bed is regulated by molasses gates placed in the manholes at the four corners of each bed.

By the process of intermittent filtration it has been shown that about 100 000 gallons of domestic sewage can be purified in each twenty-four hours on one acre of sand bed area, so that the danger of subsequent putrefaction is removed; and that using only from 20 000 to 30 000 gallons per day, the product obtained is, as far as chemical or bacterial analysis can show, as pure as spring water.

The work of the Massachusetts State Board of Health, valuable as it was, still left unsettled a number of important points, among which the most salient were: How could the sewage of cities be purified by bacteria where large tracts of sandy soil did not occur?







INTERMITTENT

FILTRATION BEDS

FIG. 1.

How could the large amount of suspended matter, like paper, wool-waste, and the other various forms of cellulose not easily acted upon by bacteria, be prevented from forming a layer and coating over the top of the sand, thus partially clogging up the sand area? Could sewage containing large amounts of manufacturing waste, especially free acid and iron salts, be treated bacterially?

The quantity of sewage that could be treated by intermittent filtration with continuous success had been shown to be not over 100 000 gallons per acre per day, a quantity so small as to be quite useless for towns and cities which would be obliged to construct beds with sand not *in situ*. This point was quickly perceived in England, where sand *in situ* is not of common occurrence, and the bacterial sewage work of England started with the problem, Can the amount of land required by the intermittent filtration method be so reduced that the construction of artificial bacteria beds will be a practical possibility?

The first work in this connection that need be mentioned is that of Dibdin and Thudichum. The experiments of the Massachusetts State Board of Health, broadly speaking, had been along lines followed in the purification of water. Dibdin and Thudichum argued that in sewage, containing, as it does, such vastly greater quantities of organic matter, the bacteria should be allowed a longer time for action than could be obtained by allowing the liquid to pass through a sand bed, and that a greater amount of work could be obtained from the bacteria if the bed were allowed to remain full of the liquid for a certain number of hours. All the micro-organisms thus being kept in contact with the liquid, they would be afforded a better opportunity for changing the organic matter into mineral matter, and the area necessary for the purification might be reduced.

The first experiments were made at Barking, not on crude London sewage, but upon sewage from which the suspended matter had been removed by chemicals. A water-tight bed, covering an acre in area, was constructed. At the bottom perforated drains meeting in a common trunk sewer were laid, and the trunk sewer was provided with a valve so that the sewage could be kept in the bed, or the bed emptied quickly, as desired. The bed was then filled with broken coke to a depth of three feet.

The method of using the bed was as follows: The valve in the trunk drain was closed, the bed was filled to the level of the surface with the above-described effluent, which contained about 0.7 parts albu-

minoid ammonia in 100 000 parts, the bed was allowed to remain full two hours and then emptied, the emptying occupying about two hours. This process was repeated three times a day except on Sundays, the bed thus being allowed to remain empty from twenty-four to thirty-two consecutive hours each week. Working in this way, the bed passed on an average 1 000 000 gallons a day, including all times of rest, and the amount of purification determined from the albuminoid ammonia was from sixty-six to seventy-seven per cent.

Though the amount of purification thus obtained did not compare with the results of intermittent filtration, the result was surprisingly good when the amount treated per acre was considered, and seemed to show that the theory of Dibdin and Thudichum as to longer and more intimate contact of the sewage with the micro-organisms was correct; and Dibdin was encouraged to carry on further experiments at Sutton, England, using crude sewage. A bed similar in arrangement, though of much smaller area, was constructed and filled, not with coke, but with broken burnt clay; and crude sewage, which had received absolutely no treatment except screening, to remove the grosser suspended substances, was run upon the bed. The time required for filling the bed was about one hour; it was allowed to remain full for about two hours and then emptied; the time occupied in emptying it was one and one half hours; the bed was then allowed to rest for two hours, after which it was again filled. The rate of flow on this bed averaged about 770 000 gallons per acre per day, rest periods included. The effluent, as I have seen it, has been clear and without strong odor, and the analyses made three or four times each month, from November, 1896, to March, 1898, showed that the "oxygen consumed" had been reduced from 4.66 parts per 100 000 to 1.77, and the albuminoid ammonia from 0.85 to 0.296 parts in 100 000, the purification equaling about sixty-four per cent. The amount of nitrification had, however, been low, only 0.66 parts of nitrogen in 100 000 parts of the filtrate being found in the form of nitrites or nitrates.

This series of experiments substantiated the results obtained at Barking, and also proved that a far better purification of sewage could be obtained in the above manner, without the formation of sludge, than by any process of chemical treatment, which, at the best, only removes fifty-two per cent. of the total organic impurity.

The effluent obtained, however, from crude sewage by the above plan, and with a bed treating over 700 000 gallons per day per acre,

does undergo secondary putrefaction, gives off odors, and pollutes small water courses.

Mr. Dibdin at once saw this to be the case, and perceived at the same time that a further purification would undoubtedly be accomplished by allowing the partially purified sewage to come in contact with a second bacteria bed; reasoning that if the first bed removed sixty per cent. of the polluting matter, why would not a second remove sixty per cent. of that which still remained? The experiment was tried; the filtrate from the first bed was run upon a second bed of the same size and construction as the first, filled, however, with burnt clay, all of which would pass a half-inch mesh, the method of working the second bed being exactly the same as with the first. The results were satisfactory, for by this double contact a purification equaling eighty-two per cent. had been accomplished, and the effluent from the second bed did not undergo secondary putrefaction or pollute a small water supply.

This was the beginning of what is known as the Double Contact Bacterial Method of purifying sewage, the action of which has been very carefully studied on a large experimental scale during the past year at Manchester, Leeds, Sheffield, Leicester, — in fact, in almost all of the large cities of England; and it is the method that has been reported on so favorably by the expert commission appointed to recommend a method of sewage purification for the city of Manchester — whose dry weather flow of sewage is twenty-five million gallons per day — that the city council of that city have adopted this method, and have accepted plans and specifications for the construction of a plant at the estimated cost of $2 400 000.

The following diagram (Fig. 2), taken by permission from a plate in the commissioners' report above referred to, gives a section of two beds of a double contact system and a ground plan of a contact bed empty, showing the under-drains, and a contact bed full of the filling material, showing the carriers for applying the sewage.

As is seen, in the double contact system the beds must be on two levels, so that the under-drains from the first bed are at least on a level with the top surface of the second bed, and so arranged that the effluent from the first bed can be run directly upon the second bed, or into the effluent channel. The valves in the under-drains are so arranged that the beds can be left filled with the purified sewage or completely emptied.

In making contact beds the ground is excavated to the depth of

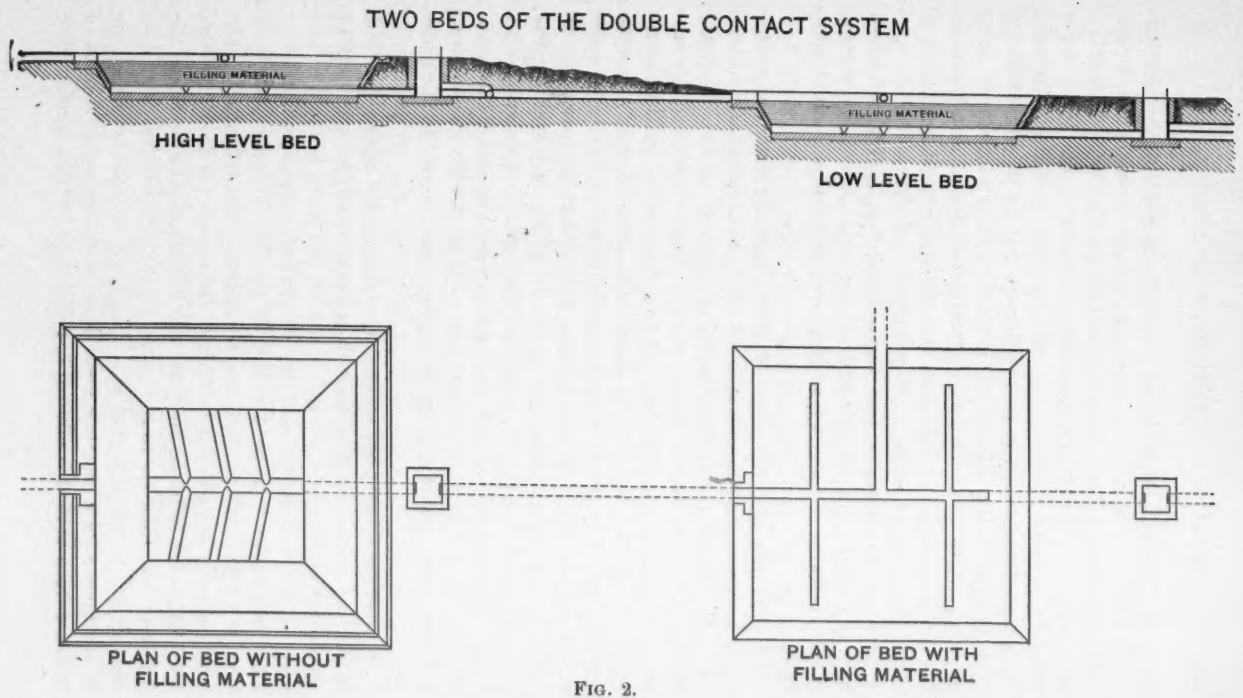

TWO BEDS OF THE DOUBLE CONTACT SYSTEM
FILLING MATERIAL
HIGH LEVEL BED
FILLING MATERIAL
LOW LEVEL BED
PLAN OF BED WITHOUT FILLING MATERIAL
PLAN OF BED WITH FILLING MATERIAL

FIG. 2.

about four feet, and the sides and bottom made water-tight; best by cement concrete six inches thick rendered with mortar one and one half inches thick. The bottoms of the beds are channeled to receive drain pipes, or the channels themselves serve as drains, being covered with perforated slabs. The effluent from these drains passes into a main drain, which is so constructed that by the use of manholes and valves the effluent can be carried from a high level to a low level bed, or can be delivered directly into the effluent channel. The construction is also such that the effluent channels can be kept full of the purified sewage or completely emptied. The sewage carriers are so arranged that the crude sewage can be delivered upon any of the beds, either high or low level, and is distributed on the beds, as a rule, by wooden carriers with perforated bottoms.

The beds are filled to a depth of three feet with almost any kind of hard, porous, jagged material. Dr. Hill, of Birmingham, prefers coal; Mr. Scudder, of Manchester, clinkers or cinders. At the Manchester experimental works coke is used; at Sutton, burnt clay. The question of the best substance to use for the filling material is a disputed one. In my opinion the material should be sufficiently hard so as not to be easily broken down; it should be more or less porous, so as to have a large water-absorbing area; and it should have a jagged surface, on which the gelatinized micro-organisms can easily be retained; and possibly broken iron slag would be a better material than any of those mentioned. Whatever the material may be, it is carefully sifted, and only that portion which passes a $1\frac{1}{2}$-inch mesh and is rejected by a $\frac{1}{4}$-inch mesh is used in filling the bed.

In using the contact bed system of treatment, the upper level bed is filled as quickly as possible with sewage, usually in a half-hour; the sewage is, as a rule, allowed to remain two hours in the bed, and then, if the determination of the amount of oxygen consumed or other test shows it to be desirable, it can be run upon a low level bed, or if sufficiently purified, directly into the effluent channel. The emptying also occupies one half-hour. If the effluent from the high level bed is run upon the low level bed it is allowed to remain on the low level bed from one to two hours, as the case requires, and then passed into the effluent channel. In a triple contact system it can be run upon a third bed on a lower level than the second. After a bed has been used it is allowed to remain empty from three to four

hours before again being filled. Used in this way the same bed can be filled three or four times a day.

The method of double or triple contacts has, it seems to me, placed in our hands a very delicate piece of apparatus, which might be called a bacterial machine, and which can be adapted to the work required in much the same way as any piece of machinery in the mechanical arts. For instance, with a very weak sewage, one contact can be used, and that not of two hours, but of one hour only. In another case, with a stronger sewage, two contacts, each of two hours, or one of two hours and the other of one hour, can be tried; while with certain kinds of sewage, which might come down the sewers at certain intervals during the day, it would be possible, in a suitably arranged plant, to use three contacts.

As to the amount of sewage that can be purified by the double contact system, it has been shown by actual work that 700 000 gallons of crude strong sewage can be purified per acre per day, so that the effluent will not undergo secondary putrefaction, either unmixed or mixed with river water.

A comparison of the results obtained by intermittent filtration system, illustrated by the results obtained at Marlboro for the year 1898, where the amount of sewage treated was 90 000 gallons per acre per day, with the results obtained at Manchester using the double contact method, and treating 700 000 gallons per acre per day, is shown in the table below. There is no question that the intermittent filtration system gives a much purer product than is obtained by the double contact method. What can be claimed for the double contact method is that with an area of filtration only one ninth of that required for intermittent filtration it gives a product that is sufficiently purified to prevent its causing any trouble or nuisance, even when emptied into a very small water course.

ANALYSIS OF SEWAGE EFFLUENT.

Parts in 100 000.

	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.	Nitrogen as Nitrites, Nitrates.	Chlorine.
MANCHESTER, ENGLAND.					
Septic tank	3.20	0.390	7.00	. . .	16.4
1st contact bed	1.80	0.170	2.20	0.052	16.0
2d contact bed	0.51	0.075	0.69	0.870	15.7

ANALYSIS OF SEWAGE EFFLUENT — *Continued.*

Parts in 100 000.

	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.	Nitrogen as Nitrites, Nitrates.	Chlorine.
		MARLBORO, MASSACHUSETTS.			
Sewage	1.90	0.4600	2.59	0.15	4.91
Effluent	0.62	0.0328	0.34	0.56	5.00
		PER CENT. REMOVED.			
Manchester	84.1	75.2	90.1	. . .	. . .
Marlboro	64.6	92.0	86.9	. . .	. . .

These results are very satisfactory and show that for a city so situated that large tracts of sand cannot be obtained, the bacterial treatment of sewage is still a possibility. The method, however, is open to the same objection as the method of intermittent filtration; namely, the clogging up of the beds by suspended matter and substances not easily acted upon by bacteria. This danger, it seems to me, is much greater in the beds of the double contact system than in the beds of an intermittent filtration plant, as the area and cubical contents of the former are so much smaller in proportion to the amount of sewage treated. This objection to the double contact system is now fully recognized, and, from the experiments made at Leeds during the past year, it would seem that double contact beds cannot continuously, for any great length of time, purify crude sewage; or, in other words, if crude sewage is applied directly to double contact beds, the filling material in the beds must be entirely removed every few years.

In our brief outline as to the action of bacteria in decomposing animal and vegetable matter, we noticed that the decomposition was brought about in two stages; the first stage consisted in the decomposing of the grosser and more complex substances occurring in sewage and bringing them into solution by means of the anaërobic bacteria, which live out of contact with air; while the second stage consisted in the complete decomposition and nitrification of the simplified products by the aërobic bacteria, to which air is a necessity. In all bacterial treatment of sewage these two stages must take place, and in the system of intermittent filtration beds and contact beds the two stages of purification are being carried on more or less at the same time. If in either of these systems too little air is supplied, or too much sewage applied to the beds, which amounts to

the same thing, the aërobic or nitrifying bacteria cease to work, their place being taken by the anaërobic bacteria which are unable of themselves to finish the process; and whenever the anaërobic bacteria have obtained the upper hand, as is the case when a bed is overworked, the bed becomes clogged and the product foul. Can this be prevented? Is it possible to treat sewage in two different stages? As I have mentioned, one of the salient questions left unsolved by the Massachusetts State Board of Health was, Could the clogging up of the surface of a sand bed area by suspended matter be prevented? This question, as well as the question which we have just considered, of increasing the amount of sewage that could be applied to a given area, has received careful study in England, and as a result we have what is now known as the Septic Tank Treatment, by which treatment the first stage of sewage purification is brought about before the sewage is allowed to come in contact with the filtration areas.

By septic treatment is meant confining the sewage for a given time out of contact with air and light. In itself it is the method of our forefathers, the cesspool, and the reactions that take place in the septic tank are similar to those which take place in cesspools, resulting in bringing into solution a large amount of suspended animal and vegetable matter. The use of a tank for this purpose is not new. Dr. S. Rideal (Cantor lecture, January, 1899) mentions the use, as early as 1858, of a large underground tank by a boarding school in England for the treatment of the sewage of three hundred persons, and Mr. Rudolph Hering has lately pointed out that the Mouras Automatic Scavenger, described in the *Cosmos les Mondes*, December, 1881, and January, 1882, was a true septic tank.

Mr. Scott-Moncrieff, the well-known sanitary engineer of Ashstead, England, was, I believe, the first to recognize that the bacterial purification of sewage took place in two stages, and that the first stage should serve as a prelude to further treatment. In 1891 he built at Ashstead a small plant in which the purification of the sewage should take place in two stages. It consisted of a closed tank filled with stones, for the partial liquefaction of the solid matter in the sewage, and of open trays containing coke, for the second stage, or where nitrification was to take place.

Fig. 3 shows the liquefying tank and the coke trays used by Scott-Moncrieff. The sewage first enters the grease trap *A* and then passes into the space *B* of five cubic feet capacity, which is under-

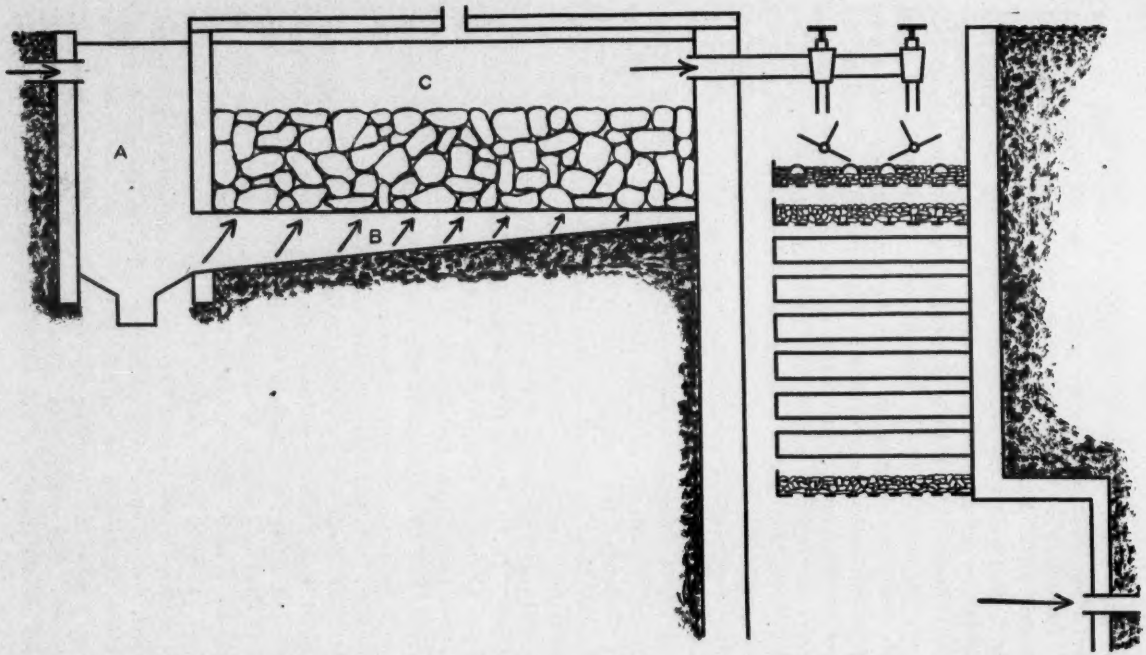


FIG. 3.

neath the gratings of the liquefying tank *C*. It then passes upwards through a bed of small stones inside the tank, and then by means of distributors passes to the uppermost of a series of nine perforated trays, containing coke, supported vertically over one another, about three inches apart. Each tray has an effective area of about one square foot, and contains seven inches of coke, broken to about one inch diameter. The time required for the liquid to pass through the nine trays is about ten minutes.

In the tank the anaërobic action takes place, and on the coke in the trays the aërobic. The anaërobic or septic action that took place in the liquefying tank when used at Ashstead was so effective that it is reported that the solid deposit of seven years from a household of ten persons was absorbed on nine square yards of land, causing no distinction in appearance between this soil and the surrounding; and the second stage of purification, nitrification, was so perfect that all the decomposable matter was destroyed.

The credit, however, of showing that a modified cesspool could be advantageously used for the preliminary treatment of the sewage of cities and towns belongs to Mr. Cameron, of Exeter, England. The process was named by him the Septic Treatment, and it is by this name that it is now known.

He built at Exeter an underground tank of cement concrete, 65 feet long, 19 feet wide, and of an average depth of 7 feet, and having a capacity of 53 000 gallons. The tank was covered with a

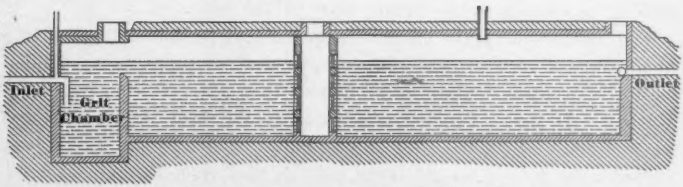


FIG. 4. — SECTION OF SEPTIC TANK.

concrete arch, and, as is shown in Fig. 4, a portion of the tank near the inlets was made about three feet deeper than the rest and partially cut off by a low wall, forming a couple of pockets or grit chambers, to retain sand, grit, and road washings. The inlet was carried down to a depth of five feet below the surface, so that air could not make its way down with the sewage, and also so that gases

could not escape from the tank back into the sewer. The effluent outlet was also below the level of the liquid, and, to avoid any current that would be liable to carry with it any floating matter from the surface, a cast-iron pipe was carried across the whole width of the tank fifteen inches below the surface, and on the lower side of this pipe there was a continuous opening of about one-half inch in width. An iron pipe, about one and one-half inches in diameter, extended out of the top of the tank to allow the escape of gases which were formed, and the sewage in the tank could be inspected by descending into a manhole constructed in the center and having glass windows.

At the plant at Exeter there are also five single contact beds 36 feet long, 20 feet wide, and 4 feet deep, made water-tight and filled with crushed clinker or coke breeze. (See Fig. 5.) Such beds are admirably adapted for the cultivation of aërobic bacteria, and the liquid as it comes from the tank, having undergone the first stage in the process of putrefaction, is now in just the right condition to be acted upon by the aërobic bacteria.

In August, 1896, the main sewer of St. Leonard's, a suburb of Exeter, with a population of 1 500, and an average daily flow of sewage of 57 000 gallons, was connected with the tank, and the above volume of sewage has been continuously passed through the tank since that time. The effluent from the tank falls over a wall about one foot high, which effects slight aëration, and then by means of the alternating gearing, devised and patented by Mr. Cameron, is caused to pass automatically to one or the other of the beds.

Visiting the plant, the effluent from the tank first strikes the attention. It is a brownish-colored fluid, free from palpable suspended matter, but does contain solid matter in a state of very fine subdivision. It has a decided odor, but at the four different places where I examined it the odor is not more offensive than that given off from the first or second basin used in the chemical precipitation process.

The liquid in the tank is covered with a thick, floating mass, dark brownish yellow in color, through which bubbles of gas are continually breaking. This floating mass was formed during the first six or eight weeks the tank was in operation, and is said not to have increased much in thickness since that time. It appears to be composed of organic matter, but in fact I believe it is principally a mass of micro-organisms, and it is not till this floating mass has been

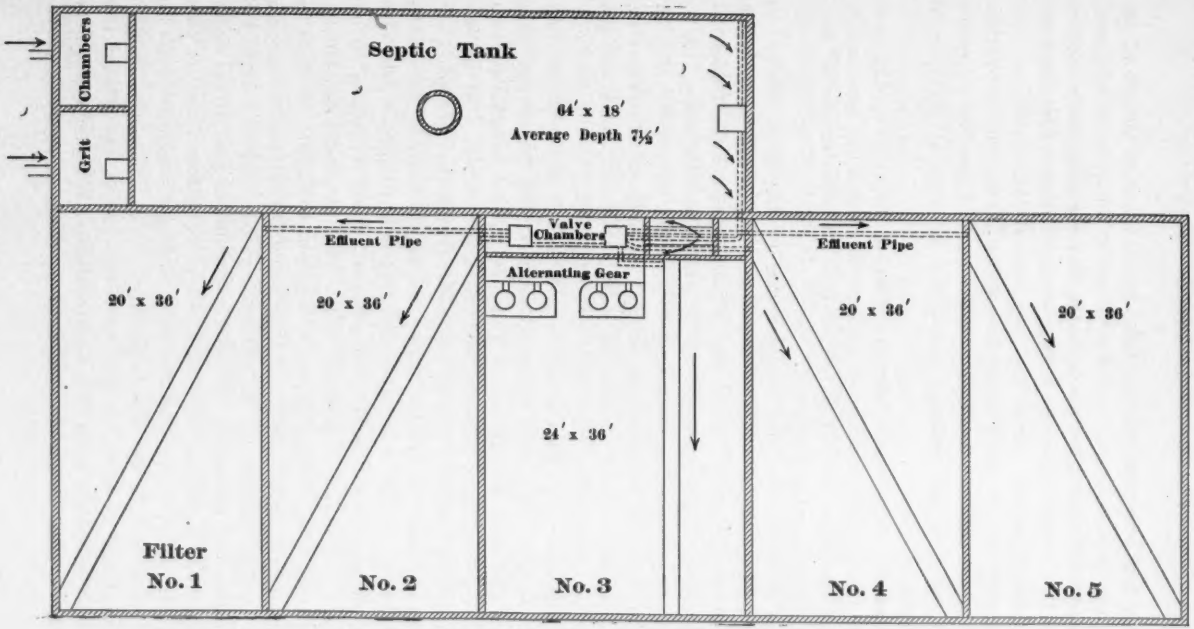


FIG. 5.—PLAN OF SEPTIC TANK AND CONTACT BEDS.

formed that active septic action takes place. At the bottom of the tank there was, last summer, a deposit two to three feet in thickness, the accumulation of three years, as the tank has never been cleaned out. This deposit looks like sewage sludge, though it contains much less organic matter. From the iron pipe at the top of the tank issues a volume of gas which, when ignited, burns with a colorless flame about one foot in height. The unignited gas has a marked odor, but does not contain appreciable amounts of sulphide of hydrogen.

What are the changes that take place in this tank? The most marked is the disappearance of solid matter, and it has been demonstrated that from one half to two thirds of the total suspended matter is decomposed and liquefied.

The decomposition and disappearance of this large amount of solid matter is explained by the theory that it is caused by the action of anaërobic bacteria. This class of bacteria has, without question, the property of decomposing cellulose and allied substances, with the formation of water, marsh gas, hydrogen, and carbon dioxide, and also the power of decomposing complex nitrogenous substances like albumen into simpler compounds, soluble in water, as marsh gas, ammonia, and carbon dioxide.

In the septic tank there would be both aërobic and anaërobic bacteria, sewage continually entering the tank, but the sewage being practically shut off from air it would be a most suitable environment for anaërobic bacteria, and we would expect that the two changes noted above would be the principal ones that took place.

The cellulose in various forms, as paper, starchy substances, woody fiber, would be disintegrated and finally liquefied; the complex nitrogenous substances, like albumen, would be broken up into simpler compounds, and those which were originally insoluble in water thus being brought more or less into solution. In these decompositions a large amount of solid matter would also be changed into gaseous compounds, as ammonia, carbon dioxide, marsh gas, hydrogen, and nitrogen. Of these, ammonia and part of the carbon dioxide would remain in solution, while the others, being insoluble in water, would escape from the tank, forming a combustible gas like that escaping from the tank at Exeter.

As a result of these changes we would expect the effluent from the tank to contain more free ammonia than the crude sewage, but much less albuminoid ammonia, and the amount of oxygen consumed

by the effluent to be also much less than that consumed by the crude sewage.

The following analyses of crude sewage and tank effluent show the results actually obtained: —

	No. 1.*		No. 2.†	
	Crude Sewage.	Tank Effluent.	Crude Sewage.	Tank Effluent.
Free ammonia	4.50	7.50	3.60	4.90
Albuminoid ammonia	1.20	0.66	1.40	0.64
Oxygen consumed	4.50	3.10	6.56	4.32
Chlorine	8.00	8.10		

These results are very similar to those which I have obtained in my experimental work at Worcester.

It is not a long step between a closed and an open septic tank, and I doubt if it is known who first saw that similar action must take place in a large open tank as in a closed tank. The conditions, of course, in both cases must be practically the same; no free oxygen can be present in an open tank when full of sewage, and as the sewage contains a large amount of suspended matter, very little light can penetrate down from the surface. I know not who first used an open tank for septic action; I found them last summer being used experimentally at Accrington, Huddersfield, Leeds, and Manchester, England. In each of these places an old tank which had formerly been used for chemical precipitation had been turned into a septic tank, all the change necessary being to place the outlet so that the effluent opening should be three to four inches below the surface of the liquid, although, of course, in the building of such a tank it would be much better to have the inlet also beneath the surface. In all these places the general appearance of the liquid in the tank was the same, very dark and opaque, the surface coated over with a thick layer of solid matter, and the activity of the action in the tank shown by the thousands of bubbles of gas escaping through this layer of solid matter. The effluent was of a dark brown color, containing suspended matter in a very fine state of subdivision; but neither the odor given off from the tank nor that from the effluent was so offensive as to prevent its use. That the action which takes place in the open septic tank is very similar to

* Average of a series of analyses made at Exeter by T. B. Perkins, Esq., public analyst.

† Average of a series of analyses made at Exeter by Dr. G. S. Rideal.

that which takes place in the closed tank is shown by a series of analyses I have lately made on the gases given off from the closed and open septic tanks at the Worcester, Massachusetts, Sewage Plant; the gas in both cases containing about the same amounts of marsh gas, nitrogen, and carbon dioxide. This same fact has also been shown to be true by the series of experiments made on the effluent from the two kinds of tanks by Mr. Fowler, of Manchester. He made daily analyses for one month of the effluent from an open tank, and of the effluent from a closed tank, both being supplied with the same sewage. The following table gives the average of these daily analyses. The results, as can be seen, are almost identical: —

AVERAGE OF ANALYSES OF EFFLUENTS.

Parts in 100 000.

	Open Tank.	Closed Tank.
Free ammonia	3.20	3.10
Albuminoid ammonia	0.50	0.51
Oxygen consumed	8.46	8.43
Chlorine	16.40	16.10

I have spoken as though the changes in the tank were solely due to direct action of bacteria. This, however, is questionable. The reactions may be, to a certain extent and possibly even to a very large extent, of a chemical nature and brought about by a class of substances known as enzymes. Enzymes are unorganized ferments, chemical substances which are the products of vegetable and animal life, and which, in minimum amounts, without being themselves used up, are able to break up and decompose large amounts of complicated and insoluble compounds. Thus the enzyme known as diastase decomposes starch; lifase, many fats; cytase decomposes and dissolves cellulose. These enzymes seem to decompose the complex organic substances by what, chemically speaking, is called hydrolysis, — the breaking up of a compound by the addition of water. In this way substances like albumen may be broken up, with the formation of nitrogen, ammonia, hydrogen, marsh gas, and carbon dioxide; substances like cellulose into hydrogen, marsh gas, and carbon dioxide. Many of the enzymes being the products of anaërobic bacteria, they would naturally occur in the septic tank, and a large amount of the decomposition may thus be chemical rather than bacterial.

Whatever may be the exact cause of the changes that take place

in the septic tank, either open or closed, by which suspended matter is brought into solution, the process, at all times when I have seen it, is about as follows: As the sewage enters the tank, the solids gradually fall to the bottom, covered with millions of bacteria. These, or their products, the enzymes, attack the solid matter at the bottom of the tank and gradually decompose it, bubbles of gas forming which collect about the fragments, causing them to rise to the surface; where, a large portion of the gas becoming detached, the solid matter again sinks, and this rising and sinking continues until the solid mass is completely decomposed. At the same time a scum begins to form on top of the liquid, and it is not till this scum is from one to two inches thick that active septic decomposition takes place. Formerly this required at least from one to two months in a new tank, but it has been shown during the past year that active septic action can be started up in a new tank in two or three days, if some of this layer from the top of an old tank is added to the liquid. This reminds one of the action of mother of vinegar, and it is not only most interesting, but of practical importance, as it will add greatly to the efficiency of septic plant installation.

The real practical value of the septic tank is that it destroys suspended matter without forming any very great amount of sludge or precipitate, thus having an advantage over any chemical precipitation process; that it seems to bring cellulose into at least partial solution, thus preventing the coating over of bacteria beds, either those of intermittent filtration or contact, with a layer more or less impervious to water; that it breaks up the more complex organic compounds, forming substances that are more easily acted upon by the nitrifying bacteria than the compounds in raw sewage. In a few words, it is a process which prepares the sewage for subsequent treatment on bacterial beds, either those of the double contact system or those of the intermittent filtration system. And if I were asked what was the most important step in advance that had been made in sewage treatment during the past ten years, or since the report of the Massachusetts State Board of Health, I think I would answer, the recognition that sewage purification should, for the best results, take place in two stages, and the devising of a method, as the septic tank treatment, for breaking up the complex organic compounds and bringing a large part of the suspended matter into solution.

Without some such preliminary treatment, I feel convinced that

any system for treating large quantities of sewage on limited areas, like the double contact system, — which is absolutely necessary for many cities, — is doomed to failure, and I also feel convinced that with the intermittent filtration method much more satisfactory results could be obtained if the sewage first received septic treatment.

Even with the most careful septic treatment of sewage, the length of time a contact bed can be used without renewal of the filling material is still an undecided question. Besides the slow breaking down of the filling material, experiments made during the past year at Leeds show that there is more or less filling up of a bed with certain organic substances, similar in nature to the humus of the soil, which are not removed from the sewage by septic treatment, and which are very slowly acted upon by micro-organisms. The exact nature and effect of this deposition requires the most careful investigation.

It may be said that in the chemical treatment of sewage we have also a method for the removal of suspended matter and preparing the sewage for filtration areas, and this is true; and in cases where sewage contains large amounts of acid and manufacturing refuse, notwithstanding the cost of the chemicals, and the formation of a large amount of sludge, a product most difficult to successfully handle, chemical precipitation might be used to advantage in place of septic treatment.

There is, however, one word of caution regarding septic treatment that I wish to give, and to emphasize at this time. Septic treatment does not consist in running sewage quickly through an open or closed tank; and if the rate of flow is so great that the sewage runs through the tank in much less than twelve hours, there is settling out of suspended matter, but there is very little septic action, and a rate of flow of twenty-four hours is much to be preferred to twelve.

At the beginning of this paper I mentioned that there was also a third important question which had been left almost untouched by the Massachusetts State Board of Health, namely, Could sewage containing large amounts of manufacturing waste be treated directly by bacterial methods? This question has not as yet been answered. Many experiments are now being made, both in this country — for instance, at Worcester — and in England, the results of which may in the near future give us some definite information regarding this point.

I have tried, in the time at my disposal, to give the present status of sewage purification. I have not, however, touched upon a phase of the question that may become a very important feature of sewage treatment, namely, continuous filtration.

As you all know, in the purification of a water supply, the filtration of the water through the sand beds is continuous, not intermittent, as it is in the processes of sewage filtration I have described.

Experiments of purifying sewage by continuous filtration have been made in this country by Professor Drown and the late Colonel Waring, and in England by Scott-Moncrieff, Ducat, Lowcock, Whittaker, and others.

This method has, during the past year, gained in importance by the fact that the new plant for the treatment of the sewage of Salford, capacity 12 000 000 gallons per day, just constructed under the direction of Mr. Joseph Corbett, the borough engineer, and the plant constructed in 1899 by Mr. Wallis Stoddard at Horfield, near Bristol, both use this method of filtration.

At neither of these plants is crude sewage used on the filters, but sewage from which the suspended matters have been removed, either by septic or chemical treatment. At Horfield the partially purified sewage is caused by a specially constructed distributor to rain down on the filter, which is composed of cinders from two to three inches in diameter, so that the liquid is never allowed to do more than moisten the surface. Continuous aëration is thus said to be obtained, and the bed works without any period of rest. Mr. Stoddard claims to be thus able to satisfactorily purify 8 000 000 gallons per acre of septic or chemically treated sewage per day.

It is not yet possible to state what will be the final outcome of this method of filtration. If it is possible, unquestionably, much larger quantities of sewage per acre can be dealt with than by the methods of intermittent filtration.

In conclusion I would say, while I think it is very doubtful if by any practical process of purification a sewage effluent will ever be obtained which is considered as safe to enter a water supply used unfiltered for household purposes, yet it would be a very rash statement to make, in view of the progress that has been made in the last twenty years in the methods of treating sewage, that a degree of purification may not some day be reached that would make such a use of treated sewage justifiable.

DISCUSSION.

The President called upon Mr. Rudolph Hering, of New York, to open the discussion on Professor Kinnicutt's paper.

MR. RUDOLPH HERING. Mr. Chairman, ladies and gentlemen: Having this summer examined the principal works of Europe, some of which the speaker has just described, I was particularly interested in his remarks; and I can state that it was the fairest and most truthful statement regarding this subject that I have yet heard on this side of the Atlantic. We were given the impression in America, from various articles appearing in English papers, that a great revolution had taken place in the matter of sewage purification; and that hereafter it might be a very easy and economical matter to dispose of this offensive material which every city has to deal with. We have, therefore, with much interest, watched the progress made in England.

At a number of points in Europe, not only in England, but also in Germany, experiments have been made with these so-called new processes; and as they have now been carried on for one and two years, it was a fairly good time to visit the points last summer.

After having seen nearly all of them, however, I must say that I returned with a good deal of disappointment, because the glowing promises which had been made did not seem to me to have been realized. I found the cities more or less altering their trial works, and excusing this and excusing that condition, with the desire of some to experiment further.

Some cities have reached conclusions fairly satisfactory. For instance, there is a report out quite recently from the city of Leeds, also one from the city of Leicester, and, as Professor Kinnicutt has already stated, quite recently a conclusion has been reached as to what they intend doing also in Manchester. That does not mean, however, that they have solved this whole question; they are simply going ahead and doing something which is better than what they have done heretofore.

In some other cities they are still carrying on experiments, not feeling at all satisfied with the results up to date. Perhaps one of the most thoroughly equipped experiment stations, in this particular line of investigation, is in Hamburg, Germany. There they have been experimenting for two years, and they don't expect to reach satisfactory results for at least a year yet; and also in Charlotten-

burg, a suburb of Berlin, they are making experiments on similar lines.

So I do not think it can be said that in Europe they have reached a final conclusion in regard to this matter. There is no question, however, that we are face to face with a method of sewage disposal, which, in the future, will be of advantage in many cities. You know, and you have heard it said this afternoon, that intermittent filtration, a system which was so highly recommended by the Massachusetts State Board of Health, gives us the purest effluent. Indeed, it is the only means known to-day by which you can get a real purification of sewage, so that the offensive organic matter and probably also the disease germs are thoroughly removed. There are cases where the effluent sewage is, chemically and biologically speaking, equal to the best drinking water; in fact, better than a good deal of the raw drinking water that we furnish our citizens in this country. No other method of sewage treatment comes up to it.

But there are a large number of cases where it is not necessary to purify sewage to that extent, and where we can adopt something which is less expensive at the sacrifice of not turning out such good water. Personally I am of the opinion, and I have held this opinion for many years, that the time is not far distant — in some places it has already arrived — when all of our drinking water must be filtered. In other words, we should not be furnished with any water other than either such that has been naturally filtered, as spring water, or such that has been artificially filtered. In Europe this principle is already being closely followed. There are but a very few cities where the water furnished does not belong to one of these two classes. Vienna gets its water supply from the mountain streams of the Alps; it does not filter it, but it protects it very carefully. Paris gets a part of its drinking water supply — it has, as you know, a double supply, one for drinking and household purposes, and the other for street washing purposes — from mountainous regions, and it is not filtered. Glasgow gets its supply, which is also not filtered, from Loch Katrine. But pretty much all of the other large cities of Europe now have either ground water or filtered water. Liverpool gets its supply from the Welsh mountains, a territory which in our country would generally be considered quite suitable for a water supply without filtration; yet filters are arranged there for the purpose of reducing its color and of guarding it against

any incidental pollution to which a water supply is liable in any country. You can't prevent sick people from going up into the mountains; you can't prevent flies and other insects from carrying disease germs from inhabited places or manured fields to the watershed. So the only safeguard which they recognize in Europe now, and which we surely will recognize later on here wherever we do not yet recognize it to-day, is that all water supplies should be filtered.

Now, if that is the case, sewage filtration is not such a serious matter, particularly in our country where we have so many large rivers and can dispose of the sewage very often by dilution without causing any offense to riparian inhabitants. This subject is of more importance in Europe, where, because they only have about one half the rainfall, their rivers are much smaller than ours. They are, therefore, developing it, and we may get from them, perhaps in a short time, some very excellent scientific results.

I would like to state, with reference to what Professor Kinnicutt said as to the Massachusetts State Board of Health originating the system of intermittent filtration, that it laid the first broad scientific foundation for that method of purifying sewage. It did not originate there, because the chemist of the city of Berlin, Dr. Alexander Müller, as early, I think, as 1865, reported on the fact that the bacteria in sewage were the cause of the purification of the sewage, when it trickled through soil slowly and intermittently. Shortly after that, Dr. Frankland of England made similar statements; and in 1870 an engineer, Bailey Denton, constructed a large filter plant at Merthyr Tydfil, in the English lake region, for sewage purification on the intermittent filtration plan, and this was the first large successful work of the kind. I saw those works myself in 1880. The Massachusetts State Board of Health began its work, I think, in 1887. After it had made its reports we knew exactly what we could expect from soils of a certain character, in the way of sewage purification. Before that time the necessary details were largely a matter of guesswork.

In examining the recent sewage purification plants in England there was one thing which struck me as particularly unfavorable. As Professor Kinnicutt has said, they have to depend on other materials than sand, because there is very little sand in England. They therefore use a good deal of coke and a material made out of clay in the following manner. They pile up layers of clay alternating with layers of coke or coal, and then burn it, so that it makes

a mass of burnt clay, which they subsequently break up in little chunks. It looks like very coarse gravel, and they use that very extensively instead of gravel. However, it is not a permanent material; I have seen it in conditions where it had become fine and crumbly. It had outlasted its original usefulness. It didn't act after some five or ten years as it acted originally. I saw the same deterioration with coke. Unless you get very hard coke, and you can't always get it, it will after a few years crumble and become fine. So that these materials are not permanent, and it is a question for calculation as to whether it is cheaper to get a more expensive permanent material, such as gravel or quartz sand, which will last longer (though it may not purify quite so much sewage at first as fresh coke will), or to occasionally replace the deteriorated coke or burnt clay with new material of the same kind. That is a question which must be decided in each case.

It seems to me that the experiments have not gone far enough yet to show just exactly what are the relative advantages of these different materials, particularly of quartz sand in relation to coke. The reason why they have not gone far with such experiments in England, although they have made a few, is because they do not have much sand to use.

Dr. Kinnicutt. I wish, first of all, Mr. President, to thank my friend Mr. Hering for his very kind remarks on my paper. He is most certainly correct in stating that the idea of purifying sewage by intermittent filtration had been considered long before the Massachusetts State Board of Health began their experiments at Lawrence. In the Royal Commissioners' Report on pollution of rivers and streams, 1870, after reviewing the various methods that had been proposed for the treatment of sewage, they say: "The process of filtration through sand, gravel, chalk, or certain kinds of soil, if properly carried out, is the most effective means for the purification of sewage."

In my remarks regarding the work of the Massachusetts State Board of Health, I only endeavored to convey the idea that the credit for demonstrating that the method was practicable on a large scale and, at the same time, a most effective method, should be given to this board.

I am glad Mr. Hering has referred to the deterioration and breaking down of the various filling materials used in contact beds, for this is one of the points which still require most careful considera-

tion. As he has said, experiments on this subject are now being made in England and also in Germany, and in two or three years we may hope to possess definite information on this subject. Personally, I believe the material should have a jagged, rather than a rounded, surface, as giving a better surface for the retention of bacteria; I think, for instance, that broken quartzite would be a better material than rounded pebbles.

I agree with Mr. Hering when he says that the first reports received from England were too sanguine, but I do think that the experiments that have been made there show that a satisfactory purification can be obtained on a much smaller area than that required by intermittent filtration: by satisfactory purification, meaning, obtaining an effluent which will not, of itself, or when run into a very small water course, undergo secondary decomposition: that, using septic tanks and contact beds, sewage can be successfully treated at the rate of about 500 000 gallons per acre per day. The question that has not, however, yet been answered is, How many years can such beds be used without the renewal of the filling material?

There is no question that a purer effluent is obtained by the intermittent filtration method than by the septic methods, yet the effluent obtained at the various plants in Massachusetts, as at Gardner, Marlboro, and Clinton, is very far from being, in any sense, a a drinking water. The effluent has a decided odor and taste, and contains a very large number of micro-organisms; further, in the spring, when, on account of snow and ice, the surface of the beds has remained untouched for a number of months, the top of the beds is covered with a nearly impervious layer of from one quarter to three quarters of an inch in thickness, composed chiefly of undecomposed organic matter. The rate of filtration at such a time is not over thirty to fifty thousand gallons per acre per day.

Mr. T. H. McKenzie.* May I ask Professor Kinnicutt whether there are places in England where in actual practice they are passing sewage through the contact filters and septic tanks, without subsequent filtration, where the effluent is turned into any drinking water streams, and where it meets the requirements of law?

Professor Kinnicutt. In answer to the question asked by Mr. McKenzie, I would say that the methods I have mentioned are as yet too new to have been tried, except on a large experimental scale,

*Civil Engineer, Southington, Conn.

at many places, and that I cannot recall at the present moment any place using the above methods, for the treatment of the total flow of sewage, where the effluent from the contact beds is run directly into a stream used for a water supply; and there is no question, if such an effluent were to be run into small streams, the water should be sand filtered before being used. As to whether the effluent from septic tanks combined with contact beds meets the requirements of the law, I would say that they fall well within the provisional standard of the Mersey & Irwell Commission, containing less than 0.14 parts of albuminoid ammonia in 100 000 parts, and consuming less than 1.4 parts oxygen. As to the processes themselves meeting the requirements of the law, I can best answer by saying that in England, in order to receive authority for loans required to cover the cost of construction of new sewage works, towns must submit their plans to the Local Government Board for approval. As to bacterial filters, this board requires that contact beds receiving septic tank or chemically treated sewage must be able to deal with three times the ordinary dry-weather flow; and, further, that the plans must also provide an extra area of land, the extent to be at least one acre for every thousand persons in the area provided with sewers. This extra land area is considered by the great majority of English sanitary engineers as a very conservative and unnecessary requirement, and they hope and believe that this condition will be changed in the near future. It should also be said that there are ways of obtaining money for the building of sewage works without obtaining the direct approval of the plans for purification by the Local Government Board; and, although it is more expensive, money has thus been obtained by certain towns.

DESCRIPTION OF EXPERIMENTAL FILTER PLANT AT PITTSBURGH, AND RESULTS OF EXPERIMENTS.

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[*Presented September 19, 1900.*]

GENERAL.

The city of Pittsburgh has a population of about 320 000, of which about 235 000 people are supplied with water by the municipal works, which pump from the Allegheny River. The remaining 85 000 are supplied by private companies, and almost all of the water for these people is pumped from the Monongahela River. We are interested at this time in the supply from the Allegheny. The water of this river, as regards turbidity, may be said to be midway between that of the streams of New England and of the Ohio and Mississippi valleys. It is occasionally very muddy, with large quantities of fine silt and clay. It is also polluted by sewage from many cities, towns, and mining villages, together with considerable mine drainage at times.

In June, 1896, the City Councils authorized the appointment of a Filtration Commission; to be composed of the mayor, the presidents of the councils, and eight representative citizens, two of whom were to be physicians. This commission, to quote the substance of the resolution, was to investigate the character of the present water supply, the effect of filtration, the advisability of establishing a filtration plant, and furnish an estimate of the cost of constructing and maintaining the same; also to investigate the feasibility and advisability of seeking other sources of supply.

Mr. Robert Pitcairn, general agent of the Pennsylvania Railroad, was chairman of the commission, and Mr. Allen Hazen, of New York City, was consulting engineer. Dr. Walther Riddle, of Pittsburgh, had charge of all chemical analyses, which were made in the private laboratory of Coster & Riddle. Mr. William R. Copeland,

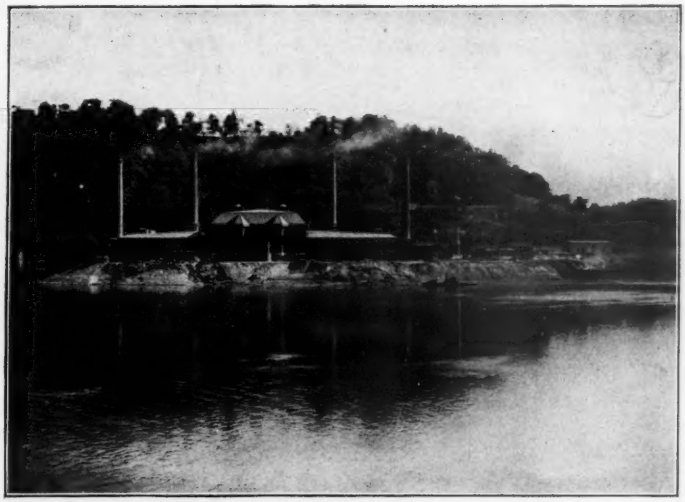

FIG. 1. — PITTSBURGH WATER WORKS. BRILLIANT PUMPING STATION AND EXPERIMENTAL FILTER PLANT.

FIG. 2. — EXPERIMENTAL FILTER PLANT. SAND FILTERS AND FILTER BUILDING.

formerly of the Experiment Station of the Massachusetts State Board of Health, at Lawrence, Mass., had charge of the bacteriological laboratory, located at the filter plant. He was also in direct charge of the operation of the experimental filters.

It is proposed in this paper to confine our attention to that portion of the investigations which was carried on at the experimental filter plant; to present a short description of the apparatus used, with views of some interesting details of the same; and to briefly summarize some of the results obtained.*

Preparations were made in May, 1897, for beginning experiments with various types of filters, and on July 23 the sand filters were placed in operation; on January 14, 1898, the mechanical filters were started. The tile filters were first started November 25, 1897, and again, after two months of idleness, on June 12, 1898. The experiments were officially closed September 1, 1898, and the report of the commission was transmitted to councils in January, 1899.

DESCRIPTION.

The experimental filter plant was located at the pumping station of the municipal water works, at Brilliant Station, on the Allegheny Valley Railway, about six miles from the City Hall. Fig. 1 shows the general arrangement, and Plate I gives some views of the plant. Plate I, Fig. 1, was taken from the north bank of the river, showing the filters and building at the extreme right. Plate I, Fig. 2, shows the settling basin and two sand filters in front of the filter building, and the elevated location of Highland Reservoir No. 1 in the background.

The plant consisted of two sand filter basins, also a settling basin of about the area of both; a filter building, in which were located the measuring vault of the sand filters, the mechanical and tile filters, the filtered water tank, the wash-water pumps and other machinery, and also the experimental boilers. Water was supplied to the plant from a large force main in the yard, and was thus of about the same character as the river water, and varied nearly as rapidly as that in the river.

* A report upon the whole subject, together with a more complete description of the experimental work and a discussion of the results, will be found in the Report of Filtration Commission, Pittsburgh, 1899. The present paper also contains the results obtained with the experimental sand filters to January, 1900.

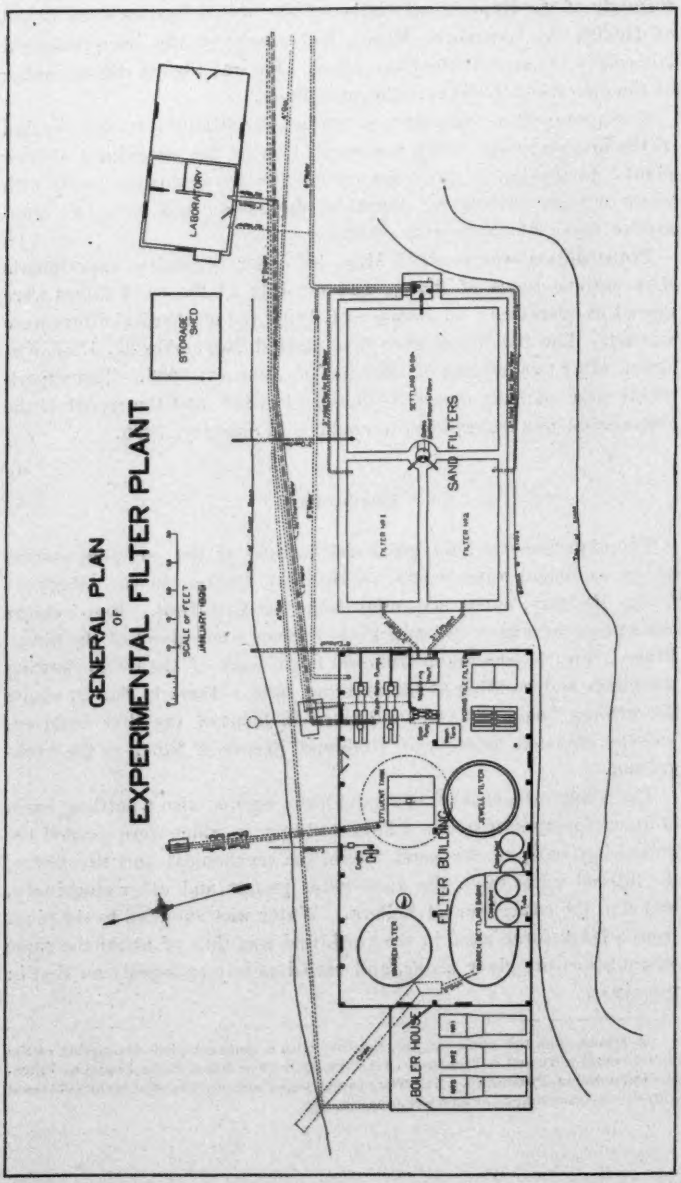
GENERAL PLAN
OF
EXPERIMENTAL FILTER PLANT
SCALE OF FEET
JANUARY 1899
LABORATORY
STORAGE SHED
SAND FILTERS
FILTER No 1
FILTER No 2
SETTLING BASIN
FILTER BUILDING
BOILER HOUSE
WARREN FILTER
JEWELL FILTER
STRUCKER FILTER

FIG. 1.

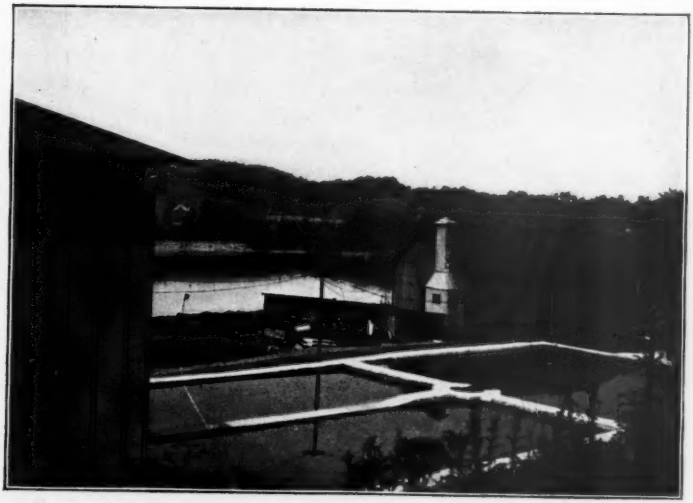

FIG. 1.—SAND FILTERS AND SETTLING BASIN.

FIG. 2.—SAND FILTER. METHOD OF SCRAPING.

SAND FILTERS.

Description. A plan and vertical section of the two sand filters are shown in Fig. 2, and a view of them is given on Plate II, Fig. 1. The entire structure — that is, walls and bottom — was built of concrete, but the filters were not covered in any way. The settling basin had a capacity of about 33 800 gallons, which, if complete displacement were realized, would have allowed twenty-four hours' sedimentation when one filter only was supplied with settled water. It is believed, however, that changes from inlet to outlet were accomplished in about two thirds of this time.

The under-drains were of vitrified pipes, four inches in diameter. Broken stone and gravel, to a depth of six inches, were placed on the concrete bottom and over the pipes. The layers of under-draining material were as follows: Three inches of broken stone of about 3 inches to $2\frac{1}{2}$ inches in size, which was covered with screenings or somewhat smaller broken chips, to close the larger interstices on top; $1\frac{3}{4}$ inches of clean river gravel of about $\frac{3}{4}$ inch to $\frac{5}{16}$ inch in size; $1\frac{1}{4}$ inches of clean river gravel which had been passed through a $\frac{5}{16}$-inch screen.

Allegheny River sand, which was deposited loosely in six layers for a depth of five feet, completed the beds. After it had settled in water for a few days the thickness had diminished to 4.2 feet, which was the amount in place at the beginning of the experiments. An average of 1.2 feet was removed during the thirteen months of operation. The average area of the sand surface was 0.0065 acre during the experiments, being about twelve square feet less at the close than at the beginning, owing to the batter of the walls. Plate II, Fig. 2, shows the method of scraping and the care taken by the attendant, by using sandals, not to make indentations in the sand surface. The average composition of the sand used may be seen in the following table: —

Results of Analyses of Sands used in the Sand Filters.

Source of Sample.	Effective Size. m.m.	Uniformity Coefficient.	Parts by Weight. Iron and Aluminum Oxides.	Calcium Carbonate.	Silicates and Insoluble Matter.
Filter No. 1 . .	0.30	2.0	0.98	1.32	97.70
Filter No. 2 . .	0.31	2.0	0.96	1.35	97.69

Apparatus. The effluent pipes were brought side by side into a small vault in the filter building, where the necessary devices were

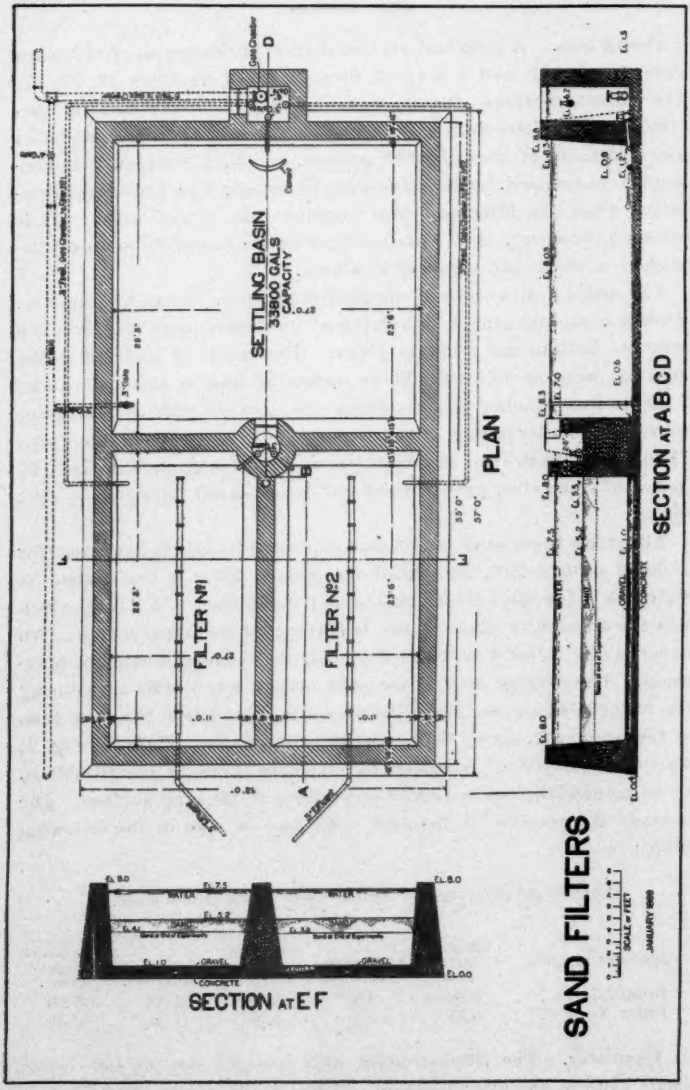
SETTLING BASIN
33800 GALS
CAPACITY
FILTER Nº1
FILTER Nº2
PLAN
SECTION AT AB CD
SECTION AT E F
SAND FILTERS
JANUARY 1899

FIG. 2.

placed for regulating and registering the rate of filtration. Meters were found unreliable on account of the amount of air in the water. Orifice indicators were therefore employed, which had the additional advantage of indicating the rate of filtration at the instant of observation. On Plate III, Fig. 1, will be seen two views of one of these indicators. Ten standard orifices were drilled in the one-eighth inch brass bottoms of copper cans, twelve inches in diameter and of the same depth. The water entered the side of the indicator and passed through a screen to prevent cross currents. On one side of the indicator there was a glass slide upon which a scale was fastened. The scale was graduated to read upon one edge in "Gallons per Orifice, Daily," and upon the other in "Million Gallons per Acre, per Orifice, Daily."

The attendant was instructed to keep the water at the half-million rate mark as nearly as possible, so that half the number of orifices open corresponded approximately to the rate of filtration. Orifices not in use were closed with rubber stoppers. The loss of head was read downward directly upon a movable scale board, the zero of which was changed frequently during the day to agree with the level of the surface of the water outside on the filter basin. Various rates of filtration were used between two million and five million gallons per acre daily, with both settled water and that which came directly from the river without any appreciable rest.

The turbidity of the river and settled waters was determined by observing the distance below the surface at which a platinum wire could be seen in the water. The record was expressed as the reciprocal of the depth, in inches, at which the wire just disappeared from view. The turbidity of the effluents was observed by comparison, in gallon bottles, with standards of known turbidity, which were made from a stock silver nitrate solution, precipitated in distilled water with sodium chloride. The relation between the two standards was determined approximately, and all results expressed in terms of the first-mentioned method.

Results. The average quantitative and bacterial results secured with the sand filters during the thirteen months are given in the following table, No. 1. The figures given in this and subsequent tables are, in some instances, slightly different from those found in the Report of the Filtration Commission. This is due to rounding up and using even figures.

Leaks and Cold Weather. In partial explanation of some of the

TABLE NO. 1.—AVERAGE OF DAILY RESULTS WITH SAND FILTERS, BY MONTHS.

MONTHS.	Hours in Operation per Day.		Rate of Filtration, Million Gallons per Acre Daily.		Turbidity.				Bacteria per Cubic Centimeter.				Percentage of Bacteria Removed.	
					Raw Water.	Settled Water.	Effluents.		Raw Water.	Settled Water.	Effluents.			
	No. 1.	No. 2.	No. 1.	No. 2.			No. 1.	No. 2.			No. 1.	No. 2.	No. 1.	No. 2.
1897.														
August	23.8	22.9	2.40	2.30	0.18	0.13	—	—	2 090	1 280	46	42	97.80	97.99
September	24.0	24.0	2.98	3.00	0.05	0.04	—	—	2 480	1 230	16	16	99.35	99.35
October	23.3	23.7	2.90	2.95	0.03	0.03	—	—	72 900	39 200	32	32	99.96	99.96
November	21.5	20.1	2.64	2.42	0.26	0.18	—	—	25 200	29 900	346	632	98.63	97.49
December	22.4	23.5	2.76	2.46	0.19	0.14	—	—	14 400	14 900	163	225	98.87	98.44
1898.														
January	22.5	22.8	2.77	1.87	0.27	0.15	—	—	15 300	13 800	334	310	97.82	97.98
February	23.5	23.4	2.93	2.27	0.15	0.10	.011	.011	9 430	12 000	266	275	97.18	97.08
March	23.5	22.7	2.95	2.83	0.28	0.17	.013	.017	11 700	12 300	71	332	99.40	97.17
April	23.4	23.5	2.95	2.99	0.08	0.08	.003	.005	5 010	4 930	33	91	99.34	98.18
May	23.6	23.6	2.93	2.95	0.19	0.12	.012	.011	10 800	6 770	110	99	98.98	99.08
June	22.8	22.9	2.83	2.85	0.19	0.11	.011	.012	11 100	5 930	135	72	98.78	99.35
July	23.5	23.6	2.94	4.97	0.11	0.07	.003	.003	16 800	13 000	74	89	99.56	99.47
August	22.8	23.1	2.85	4.82	0.36	0.25	.008	.017	15 100	10 250	51	82	99.66	99.46
Average, 13 months,	23.1	23.1	2.83	2.98	0.18	0.12	—	—	16 400	12 800	128	176	99.22	98.93

NOTES.—Filter No. 1 was operated with settled water all the time, except for occasional days.

Filter No. 2 was operated with water not settled, but applied directly from the river, from July 24 to December 19, 1897, and from February 20 to June 30, 1898; and at other times with settled water.

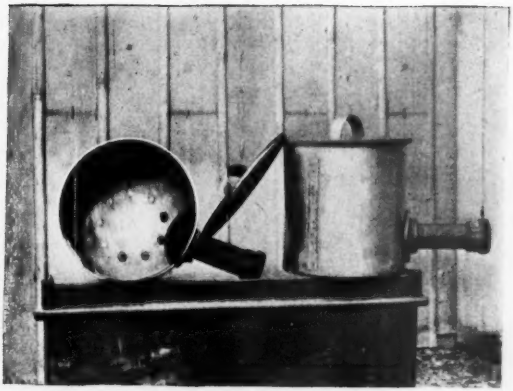

FIG. 1. — SAND FILTERS. ORIFICE INDICATORS.

FIG. 2. — SAND FILTERS. REMOVAL OF ASBESTOS FILM.

high bacterial results obtained during the cold weather, attention should be called to the cracks in the wall between the settling basin and the filters, the effect of which apparently first showed in the effluents about the middle of November, 1897. At this time it was endeavored to repair these cracks by closing them on the settling basin side, and it was then believed that this attempt was practically successful. In June, 1898, however, a small leak was again noticed; this time a small trough was built out under the opening, so that the water was compelled to pass out into the sand, instead of down along the wall. After this no trouble was noticed. Danger from cracks of this kind is lessened by placing the filter sand on the bottom for a short distance around the walls, instead of having the gravel and broken stone up close. But much safer also is that construction which provides for a settling basin some distance from the filters, so that there is something better than a concrete wall between polluted and purified water. It is probable, however, that the lower bacterial efficiency in the winter was due in some degree to the disturbing influences of low temperature, especially upon the sand surface when exposed for scraping, upon these open and unprotected filters.

Recent Data. Through the kindness of the director of public works, Mr. E. M. Bigelow, of the superintendent of the Bureau of Water, Mr. A. B. Shepherd, and of Mr. William R. Copeland, now bacteriologist-in-charge, the writer is enabled to present, in Table No. 1A, a summary of results obtained by the Bureau of Water since September, 1898. The results for the winter months are in line with those in Table No. 1, and show markedly the influence of the cold weather.

In June, 1899, the upper foot (approximately) of the sand then remaining in the filters was removed, and new sand was placed in them to a depth of three feet; then about nine inches of the old material was replaced, bringing the sand surface about to the original grade. For this reason the average results for the first six days of June, 1899, are reported separately from those for the last nineteen days. However, the average for the year 1899 was obtained by using an average for June, giving the proper weight to the duration in time of each group of results.

Five baffle walls were used after August 23, 1899, in one half of the settling basin, which caused the water applied to Filter No. 2 to travel in a tortuous course, horizontally, and thus gave a more complete displacement.

TABLE NO. 1A. — AVERAGE OF DAILY RESULTS WITH SAND FILTERS, BY MONTHS.

(AFTER AUGUST, 1898.)

MONTHS.	Hours in Operation per Day.		Rate of Filtration, Million Gallons per Acre Daily.		Turbidity.				Bacteria per Cubic Centimeter.				Percentage of Bacteria Removed.	
					Raw Water.	Settled Water.	Effluents.		Raw Water.	Settled Water.	Effluents.			
	No. 1.	No. 2.	No. 1.	No. 2.			No. 1.	No. 2.			No. 1.	No. 2.	No. 1.	No. 2.
1898.														
September	23.4	22.1	3.04	4.67	0.04	0.03	.004	.006	18 100	17 500	54	120	99.70	99.34
October	23.8	21.9	2.90	4.62	0.11	0.09	.003	.003	35 200	34 600	100	140	99.72	99.60
November	23.7	20.7	3.09	2.61	0.10	0.10	.010	.009	15 700	12 000	190	325	98.79	97.93
December	22.0	22.7	2.85	2.73	0.11	0.08	.005	.006	22 400	19 400	940	850	95.80	96.21
Average, 1898	23.2	22.7	2.92	3.35	0.17	0.11	.008	.009	15 700	13 600	197	233	98.75	98.58
1899.														
January	24.0	23.3	3.06	3.01	0.15	0.13	.016	.012	29 700	38 300	506	360	98.30	98.79
February	22.4	23.4	2.97	3.10	0.15	0.10	.008	.007	12 600	16 200	380	340	96.99	97.31
March	23.3	23.4	3.15	2.95	0.21	0.18	.021	.021	17 400	16 800	179	282	98.97	98.38
April	23.3	23.3	3.17	3.08	0.10	0.09	.016	.012	7 000	7 110	65	64	99.07	99.09
May	22.4	23.5	2.99	3.12	0.14	0.13	.008	.012	10 000	9 810	114	128	98.86	98.72
June, 6 days	23.2	24.0	3.07	3.12	0.18	0.09	.012	.010	5 730	3 840	79	106	98.62	98.15
June, 19 days	24.0	23.9	2.02	2.00	0.16	0.13	.016	.016	13 600	4 900	1 500	1 010	89.00	92.60
July	22.2	22.8	2.40	2.44	0.20	0.18	.011	.015	8 250	4 640	218	128	97.36	98.45
August	23.2	23.4	2.92	2.89	0.27	* 0.24 0.17	.015	.016	20 400	* 14 900 18 700	56	86	99.73	99.58
September	23.2	23.2	2.93	2.94	0.16	* 0.15 0.13	.010	.009	23 600	* 15 800 16 100	56	44	99.76	99.81
October	23.2	23.3	2.97	2.97	0.04	* 0.04 0.04	.002	.002	41 500	* 29 900 26 500	48	45	99.88	99.89
November	21.7	21.7	2.68	2.64	0.15	* 0.14 0.13	.006	.005	13 500	* 10 900 16 200	405	79	97.00	99.41
December	23.0	22.6	2.64	2.79	0.18	* 0.17 0.14	.012	.013	15 000	* 13 300 12 400	121	165	99.19	98.90
Average, 1899	23.0	23.1	2.85	2.84	0.16	0.13	.012	.012	17 600	15 400	272	207	98.45	98.82
January, 1900	21.7	21.1	2.44	2.34	0.19	* 0.14 0.13	.012	.014	22 100	* 27 800 21 400	463	535	97.90	97.58

NOTES. — Settled water was applied to both filters all the time, except for occasional days.
Averages of both periods in June, and, for records starred, the average of both results, were used in computing yearly averages.
* First result given where starred refers to water applied to Filter No. 1, and second result to that applied to Filter No. 2.

Asbestos pulp was used on the surface of Filter No. 2 in different quantities, from October 27 to November 12, 1898. From November 2 to December 13, 1898, sulphate of alumina was added to the applied water, as it entered the settling basin, at rates varying from one quarter of a grain to one grain per gallon. Neither of these special experiments was productive of conclusive evidence, as the time of trial was limited, and the facts are recorded here solely in order that the full history to accompany Table No. 1A may be given. Plate III, Fig. 2, shows how the asbestos pulp may be rolled up like a carpet when dried to the proper degree.

Periods between Scrapings. The following tables, No. 2 and No. 2A, contain the results of the runs between scrapings, the first until September, 1898, and the second from that time to January, 1900. The results for Filter No. 1, in Table No. 2, differ slightly from the summaries given in the Report of the Filtration Commission, as the data has been entirely recalculated from the original records, to give the result at the exact time that the loss of head reached four feet.

Not all the periods have been included in Table No. 2A. When special tests with asbestos were conducted and when, for experimental purposes, very small depths of sand were removed at a scraping, which created for the next run a large initial loss of head, greater than one foot, some of the results are omitted from the tables.

In Tables No. 2 and No. 2A, it will be noticed that there appears to be some relation between the length of period, or quantity filtered between scrapings, and the average turbidity for the period. In general, the more turbid the water, the less the length of the period and the less the quantity filtered, but the relation is not an exact one. On the diagram, Fig. 3, the results in Tables No. 2 and No. 2A have been plotted, using the quantity filtered as ordinates, and as abscissæ the square of the average turbidity during the period divided by the average rate of filtration. It will be seen that many points are some distance away from the average line, yet there does seem to be some general relation.

It may be that the storage of suspended matter in the sand, as evidenced by the turbidity of the effluent long after the muddy water has passed by, affects the length of the period to some degree. The length of the period is also undoubtedly influenced somewhat by the variation in the temperature of the applied water; the low temperature in winter causing a greater loss of head than in the warmer

TABLE NO. 2.—QUANTITATIVE RESULTS OBTAINED DURING EACH PERIOD OF OPERATION WITH THE SAND FILTERS, THE LOSS OF HEAD BEING LIMITED TO FOUR FEET.

Number of Period.		Number of Days.		Average Turbidity.				Quantity Filtered, Million Gallons per Acre.		Depth of Sand in Feet Removed at Scraping.	
				Applied Water.		Effluent.					
No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.
1	2	22.8	14.7	0.12	0.27	—	—	44.6	30.8	0.04	0.04
2	3	45.7	37.1	0.06	0.06	—	—	135.9	111.3	0.06	0.04
3	4	32.9	37.0	0.03	0.04	—	—	98.8	111.8	0.05	0.06
4	5	17.9	4.2	0.20	0.54	—	—	53.1	12.1	0.05	0.07
—	6	—	11.0	—	0.24	—	—	—	32.7	—	0.09
5	7	18.2	21.4	0.15	0.16	—	—	54.1	51.0	0.13	0.05
6	8	12.1	17.0	0.07	0.18	—	—	36.0	34.1	0.03	0.04
7	9	12.1	9.4	0.21	0.14	—	0.022	35.9	18.6	0.05	0.10
8	10	11.2	29.1	0.10	0.10	0.012	0.011	33.1	69.1	0.10	0.06
9	11	30.5	18.6	0.10	0.13	0.012	0.009	91.3	56.8	0.07	0.06
10	12	26.4	4.2	0.21	0.98	0.014	0.046	79.8	12.3	0.12	0.13
—	13	—	14.4	—	0.14	—	0.013	—	43.8	—	0.07
11	14	32.8	26.4	0.06	0.08	0.002	0.002	99.2	81.1	0.07	0.07
12	15	33.3	23.8	0.10	0.21	0.014	0.015	100.2	72.1	0.07	0.10
—	16	—	16.1	—	0.22	—	0.008	—	48.4	—	0.11
13	17	30.0	17.2	0.12	0.15	0.007	0.013	90.4	69.3	0.09	0.06
14	18	30.8	22.5	0.21	0.07	0.003	0.001	92.8	114.4	0.13	0.07
—	19	—	17.7	—	0.28	—	0.012	—	89.5	—	0.12
Average		25.5	19.0	0.12	0.15			74.7	58.8	0.08	0.07

TABLE NO. 2A. — QUANTITATIVE RESULTS OBTAINED DURING EACH PERIOD OF OPERATION WITH THE SAND FILTERS, THE LOSS OF HEAD BEING LIMITED TO FOUR FEET.

(AFTER AUGUST, 1898.)

Number of Period.		Number of Days.		Average Turbidity.				Quantity Filtered, Million Gallons per Acre.		Depth of Sand in Feet Removed at Scraping.	
				Applied Water.		Effluent.					
No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.
16	20	29.8	22.3	0.05	0.09	0.006	0.018	72.3	112.3	0.05	0.09
17	21	30.6	33.8	0.06	0.03	0.001	0.002	71.7	179.1	0.09	0.09
18	—	19.8	—	0.10	—	0.014	—	64.0	—	0.07	—
19	27	10.2	13.4	0.05	0.04	0.004	0.000	33.9	41.6	0.10	0.24
20	28	16.2	13.4	0.04	0.09	0.000	0.002	51.2	41.2	0.09	0.09
21	—	9.9	—	0.20	—	0.016	—	30.7	—	0.15	—
22	29	34.1	28.1	0.12	0.14	0.013	0.014	100.6	86.6	0.11	0.17
23	30	12.3	27.3	0.05	0.06	0.005	0.006	39.4	84.1	0.09	0.08
24	31	30.1	30.2	0.20	0.21	0.022	0.019	96.3	94.0	0.24	0.12
25	32	31.3	36.1	0.11	0.12	0.020	0.016	98.5	109.7	0.09	0.06
26	33	23.2	38.2	0.04	0.10	0.005	0.011	76.3	121.8	0.04	0.06
27	—	15.0	—	0.11	—	0.011	—	18.4	—	0.04	—
28	34	19.4	19.1	0.16	0.16	0.012	0.015	38.3	37.8	0.05	0.06
29	35	17.0	18.0	0.14	0.17	0.012	0.016	48.0	48.9	0.19	0.08
30	36	23.0	23.0	0.21	0.23	0.016	0.019	70.1	73.7	0.06	0.08
31	37	23.0	28.0	0.22	0.12	0.012	0.010	69.7	82.6	0.11	0.10
32	38	38.0	36.5	0.06	0.05	0.004	0.003	118.2	107.4	0.06	0.04
33	39	10.0	6.0	0.12	0.13	0.002	0.001	29.4	20.9	0.03	0.02
34	40	9.6	10.0	0.09	0.09	0.007	0.004	31.0	30.6	0.05	0.05
35	41	9.0	11.0	0.13	0.12	0.007	0.007	26.4	32.5	0.04	0.05
36	42	8.2	10.5	0.06	0.06	0.008	0.008	23.0	26.4	0.03	0.04
37	43	5.2	3.5	0.25	0.33	0.007	0.017	14.3	9.5	0.08	0.04
Average		22.5	26.3	0.11	0.11	0.010	0.010	64.6	87.2	0.10	0.10

NOTES. — During periods 22-26, inclusive, for filter No. 2, asbestos was used on the surface.
For the last five periods of each filter, small depths of sand were removed at scrapings, which caused an initial loss of head greater than one foot, and decreased the lengths of the periods. The results of these periods were not used in computing the averages.

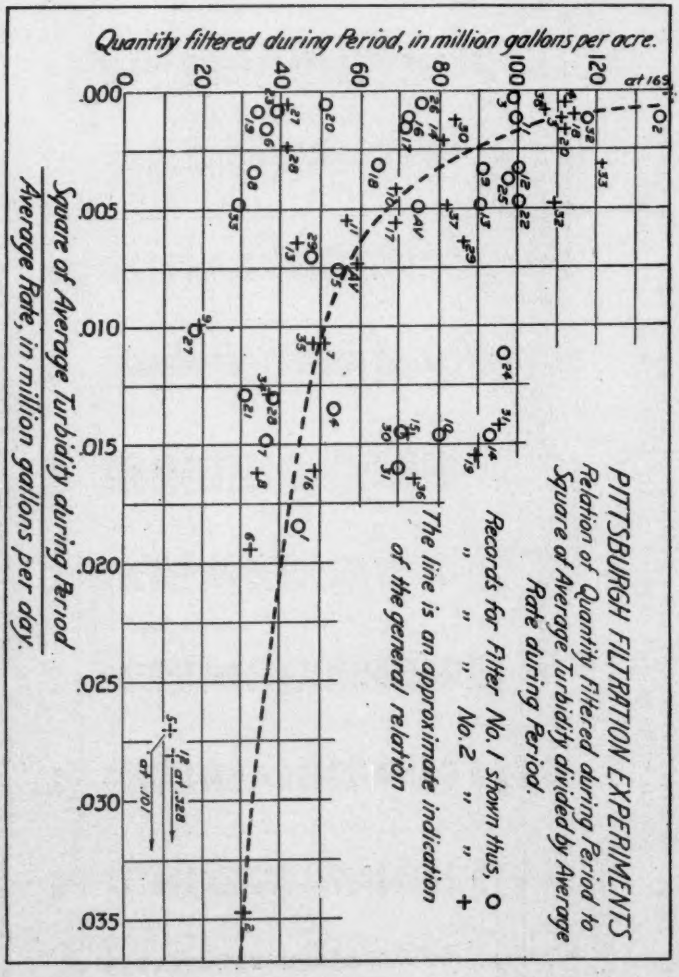
PITTSBURGH FILTRATION EXPERIMENTS
Relation of Quantity Filtered during Period to Square of Average Turbidity divided by Average Rate during Period.
Records for Filter No. 1 shown thus, O
" " " No. 2 " " +
The line is an approximate indication of the general relation
Quantity filtered during Period, in million gallons per acre.
Square of Average Turbidity during Period / Average Rate, in million gallons per day.
0
20
40
60
80
100
120
at 165
.000
.005
.010
.015
.020
.025
.030
.035
at .228
at .101

FIG. 3.

weather, to filter the same quantity. It is probable, however, that these factors are obscured by the errors in determining the effect of the water upon the filters, in regard to depositing a clogging layer, but, more than anything else, the diagram teaches us that a more accurate method of observing turbidity is needed.

The question of this relation is an interesting and even an important one, for if, by continuous and systematic observations of the turbidity of a source of supply, the probable quantity of water that will be filtered between scrapings can be determined, the largest item of the cost of maintenance of slow sand filters may be accurately estimated without waiting for the actual trial of filters.

TABLE NO. 3.—AVERAGE RESULTS OF CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM THE ALLEGHENY RIVER AND SAND FILTERS DURING THE THIRTEEN MONTHS ENDING AUGUST 31, 1898.

(Parts per 100 000.)

CONSTITUENTS.	River Water.	Outlet from Settling Basin.	Effluents.		Percentage of Constituents Removed.	
			No. 1.	No. 2.	No. 1.	No. 2.
Color	0.29	0.27	0.09	0.09	69	69
Nitrogen as						
Albuminoid Ammonia	0.0116	0.0108	0.0063	0.0064	46	45
Free Ammonia	0.0019	0.0019	0.0016	0.0016	16	16
Nitrites	0.0000	0.0000	0.0000	0.0000	..	..
Nitrates	0.0684	0.0641	0.0715	0.0647	– 5	5
Chlorine	2.19	2.08	2.06	2.02	6	8
Total Solids	15.9	13.1	12.1	12.1	24	24
Suspended Matter	4.2	1.3	0.0	0.0	100	100
Total Hardness	3.58	3.69	4.72	4.83	– 32	– 35
Alkalinity	2.89	3.07	4.13	4.22	– 43	– 46
Sulphuric Acid	1.44	1.38	1.44	1.44	..	..
Iron	0.052	0.060	0.016	0.018	69	65

Chemical Results. Table No. 3 gives the average results, for the whole period of the test, of the chemical analyses of samples of water collected from the Allegheny River, from the outlet of the settling basin, and of the sand filter effluents, together with the percentage of chemical constituents removed. Tables 12A to 12E, at the end of this paper, contain the monthly averages of the results of the chemical analyses and average summaries for different periods.

WARREN FILTER.

This filter was located in the westerly portion of the filter building. Fig. 4 shows a plan and Fig. 5 an elevation. The system consisted of a settling basin, having baffle walls, and a circular tank, or filter proper, which contained the filter sand, agitating, washing, and regulating devices.

Settling Basin. The capacity of the settling basin was about 11 200 gallons, which gave, if complete displacement were accomplished, a period of about fifty minutes for the water to pass from one end to the other, when the filter was operated at a rate of 120 million gallons per acre daily. Just before the water entered the settling basin it was measured by a meter and then at the entrance was controlled by a butterfly valve, which was attached to a float in the basin. Next, the water passed through a propeller which operated the revolving coagulant pump, or tympanum, on the platform above.

Coagulant. The solution of coagulant was introduced as the water passed the propeller. The average composition of the sulphate of alumina, which was the coagulant used in both Warren and Jewell filters, was: —

	Parts by Weight.
Alumina oxide, soluble in water	17.18
Iron oxide	0.00
Sulphuric acid	38.66
Material insoluble in water	0.24

The coagulant solution was dissolved in two tubs placed on top of the settling basin, and allowed to flow first from one, then from the other, into the tank in which the tympanum was placed. The inner end of each arm of this pump was connected to one of a series of six tubes placed in the hub and parallel to the shaft. As the pump revolved, each arm in turn was filled; as the arm became elevated, the solution passed down into the hub, out into a lead cup on the side of the tank, and thence to the settling basin below. A view of the coagulant tubs with tank and tympanum is shown on Plate IV, Fig. 1, and the exit of pipe in the settling basin in Fig. 2 on the same plate.

The level of the solution in the pump tank was kept as constant as possible by rubber float valves. It was found, however, that

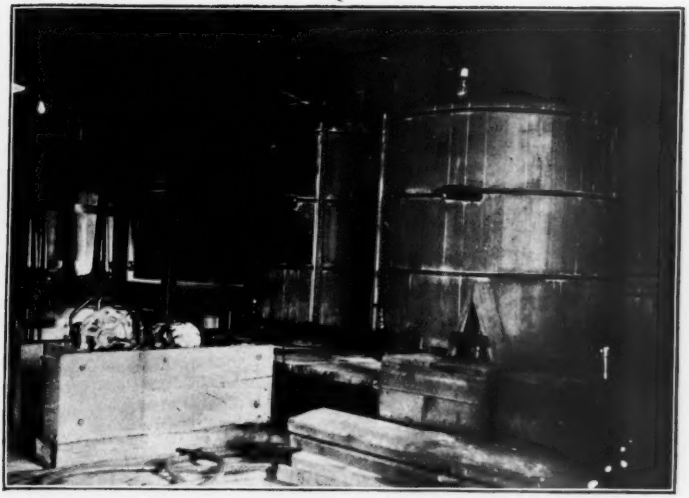

FIG. 1. — WARREN FILTER. COAGULANT TUBS AND CHEMICAL PUMP.

FIG. 2. — WARREN FILTER. INLET TO SETTLING BASIN.

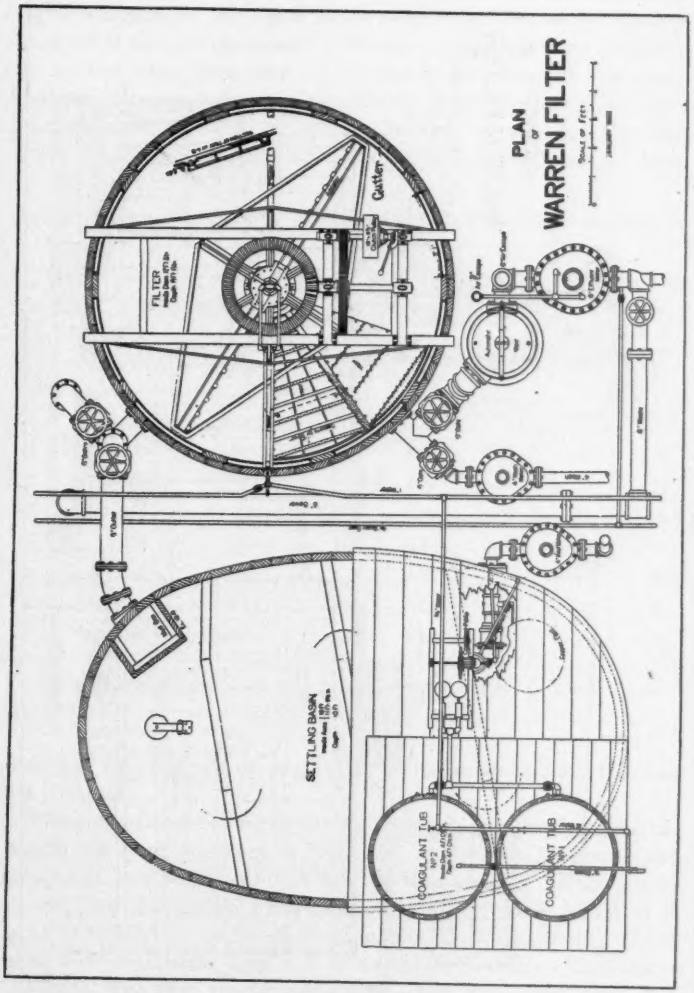
PLAN
OF
WARREN FILTER
Cutter
FILTER
SETTLING BASIN
COAGULANT TUB
COAGULANT TUB

FIG. 4.

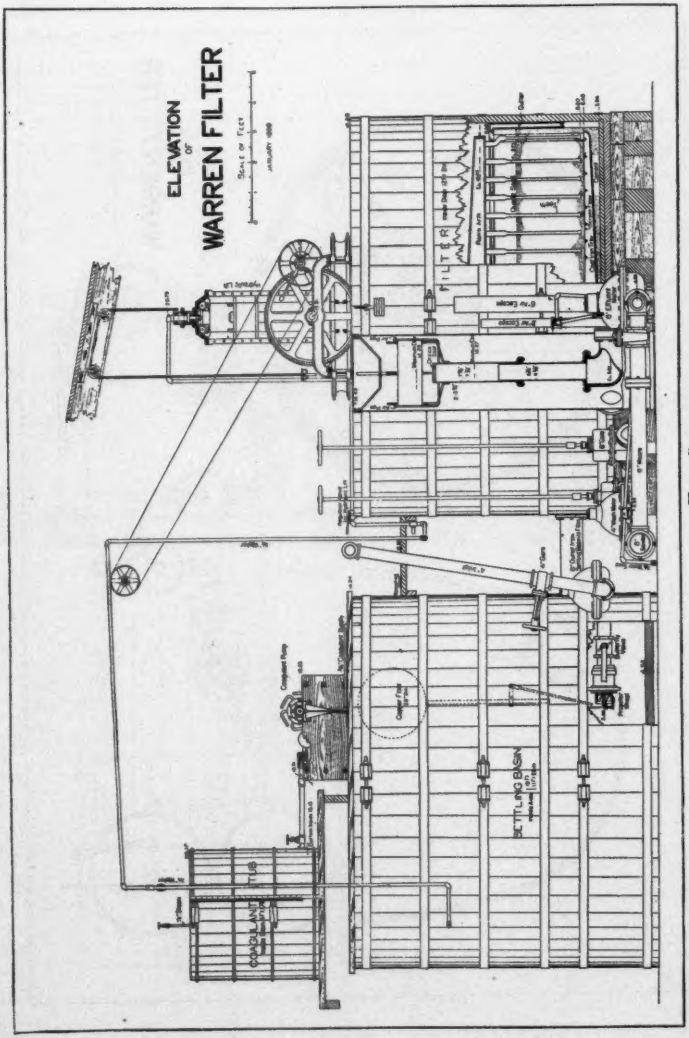

FIG. 5.

this method was not entirely satisfactory, as the valves frequently became clogged. Also, when a new solution was first used, the higher elevation of the liquid in the pump tank, due to the pressure from a full tub above, caused much more coagulant to be added to the applied water than when the solution in the upper tub had nearly run out. It was endeavored to remedy this by opening the valve from the coagulant storage tub a little only at the beginning and gradually increasing this opening as the tub became empty. Even

TABLE NO. 4.—VARIATIONS IN THE APPLICATIONS OF COAGULANT TO MECHANICAL FILTERS.

Number of Experiment.	Calendar Date of Experiment, 1898.	Name of Filter.	Amount of Sulphate of Alumina Used, in Grains per Gallon.			Percentage of Variation from he Average.	
			For Duration of Thirty Minutes.		Average for Duration of Experiment.		
			Highest.	Lowest.		Highest.	Lowest
1	April 14	Warren	0.91	0.39	0.55	+ 66	- 29
2	„ 14	Jewell	0.53	0.26	0.34	+ 56	- 24
3	June 10	Warren	2.48	0.80	1.30	+ 91	- 38
4	„ 23	„	3.96	0.66	2.19	+ 81	- 70
5	„ 23	Jewell	2.48	1.05	1.90	+ 31	- 45
6	August 12	Warren	3.86	0.91	1.57	+ 146	- 42
7	„ 12	Jewell	2.09	0.65	1.11	+ 88	- 41
Averages,			2.33	0.67	1.28	+ 82	- 48

with this care the rate of application of the coagulant solution was not constant.

Without quoting in detail the tables which are published in the report, the brief summary in Table No. 4 will show the nature and amount of this variation, both for the Warren and Jewell filters. It must be remembered, however, in studying this table, that it is more difficult to apply small quantities of a coagulating liquid in an accurate manner than it is to do similar work on a large scale.

Filter. The filter proper was composed of a circular tank with a sand area of 118 square feet. On the bottom, inside, there were placed radial iron troughs, set in concrete, which served as a sup-

port for a brass strainer floor, and also as collectors for the filtered water. From the bottom of the tank and connected directly with the inlet pipe, there was a central well which extended up through the filter floor, and above the sand surface. Attached to this well and between the collecting troughs, there were ten two-inch horizontal pipes, which were connected with vertical iron gutters, placed around the filter inside the staves.

The inlet water from the settling basin was distributed over the sand surface from the central well, and from the circumferential gutters. Plate V, Fig. 1, shows the collecting troughs, with ribs for supporting the screens, and Plate V, Fig. 2, shows the central well, circumferential gutters, and two-inch connecting pipes at the time the filter was being dismantled.

The sand used was crushed quartz, which was angular at first, but the sharp edges became rounded after some months of use. The effective size was 0.63 mm. and the uniformity coefficient was 1.1. The sand was 2.3 feet deep and rested directly on the brass strainer floor, which contained 292 900 holes, each being 0.024 inch in diameter.

Regulating Weir. After passing through the sand, the water was collected in the radial troughs, and from a central annular compartment passed to the chamber of the so-called automatic weir. The principle of this device was that of a changeable orifice plate in a sliding pipe attached to a large copper float, thus endeavoring to maintain approximately the same head upon the orifice. In fact, however, the quantities filtered were somewhat less before washing than immediately after. The extent of the variation will be seen, for some representative periods, in Table No. 5. This controlling weir was the cause of over-registration of the effluent meter, due to the presence of air needed to properly operate the weir. This error was as large as thirteen per cent. and varied in the beginning, but, by the application of air escape pipes at proper places between the weir and the meter, the error was reduced and maintained at a constant rate of four per cent.

Washing. Filtered water was furnished for washing by two duplex steam pumps, size 12 × 7 × 18 inches, which drew the water from a large effluent tank under the building. The wash-water was measured by a meter, then entered the filter by the effluent pipe, and passed up through the screens and sand in the opposite direction to that of the current of water when filtering. As the dirty water flooded above

FIG. 1. — WARREN FILTER. COLLECTING TROUGHS AND SCREEN SUPPORTS.

FIG. 2. — WARREN FILTER. DISMANTLED INTERIOR, SHOWING CENTRAL WELL, RADIAL TROUGHS, CIRCUMFERENTIAL GUTTERS, AND CONNECTING PIPES.

the sand, it overflowed down the central well and the circumferential gutters, and passed out through a waste pipe to the sewer.

Agitator. At the time of washing, the agitator was made to rotate through the sand at the rate of three turns to the minute, thus stirring the mass to the bottom. This device consisted of two horizon-

TABLE NO. 5.—VARIATIONS IN THE RATES OF FILTRATION WITH MECHANICAL FILTERS.

Number of Experiment.	Calendar Date of Experiment, 1898.	Name of Filter.	Quantity Filtered in Gallons.			Percentage of Variation.		
			For Duration of Thirty Minutes.		Average for Duration of Experiment.	From the Average.		Total between Extremes.
			Highest.	Lowest.		Highest.	Lowest.	
1	April 14	Warren	8 670	6 380	7 550	+ 15	- 15	30
2	„ 14	Jewell	6 420	5 210	5 740	+ 12	- 9	21
3	June 10	Warren	7 720	4 520	5 780	+ 34	- 22	56
4	„ 23	„	7 110	5 360	6 330	+ 12	- 15	27
5	„ 23	Jewell	6 290	5 260	5 780	+ 9	- 9	18
6	August 12	Warren	9 260	5 170	7 360	+ 26	- 30	56
7	„ 12	Jewell	8 580	2 680	5 550	+ 55	- 52	107
Averages,			7 720	4 940	6 300	+ 23	- 22	45

tal arms, 180 degrees apart, connected to a central vertical shaft, the latter being turned by gearing driven from power, which in this case was furnished by a small engine on the floor. On each of the arms were nine teeth, which cleared the strainer bottom by 0.14 foot, when the agitator was in the lowest position. The device was raised and lowered by means of a hydraulic lift placed on top of the central shaft, the whole being supported upon I-beams, placed on top of the filter. Plate VI, Fig. 1, shows the gearing of agitating system and hydraulic lift on top of filter, and Plate VI, Fig. 2, shows the rakes extending down from the arms, just touching the sand surface.

JEWELL FILTER.

This filter was located in the central portion of the filter building. Fig. 6 shows a plan and Fig. 7 an elevation. The plant consisted of

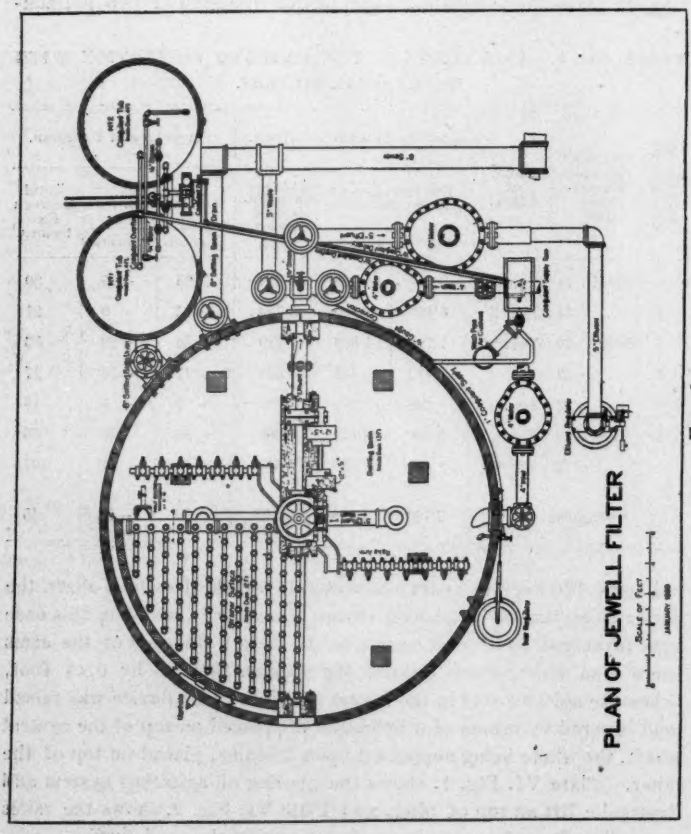

FIG. 6.

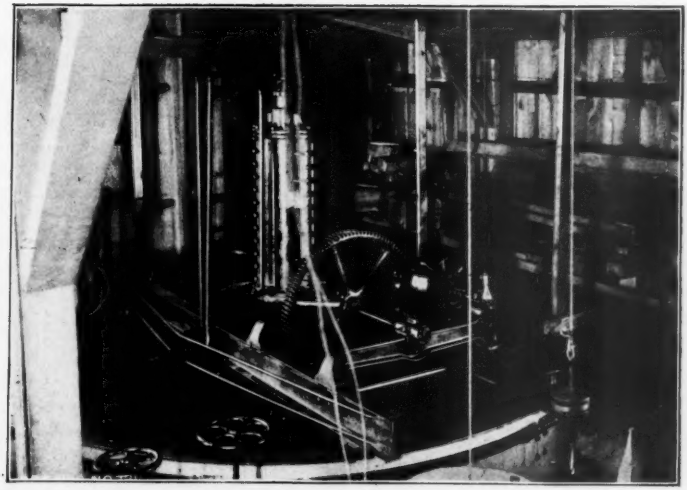

FIG. 1. — WARREN FILTER. HYDRAULIC LIFT AND AGITATOR GEARING.

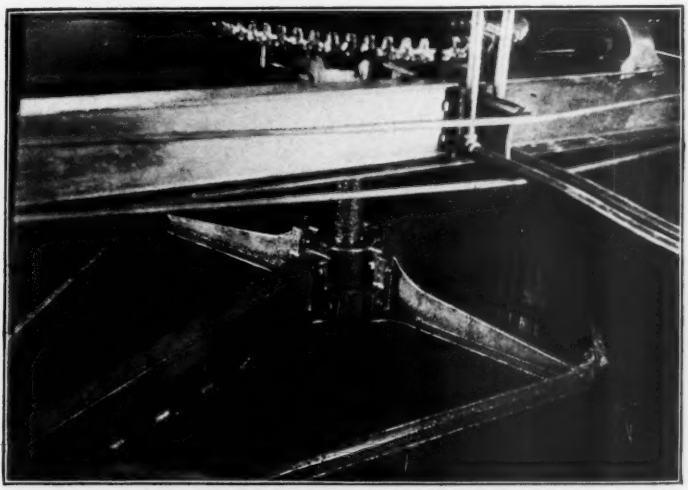

FIG. 2. — WARREN FILTER. AGITATOR.

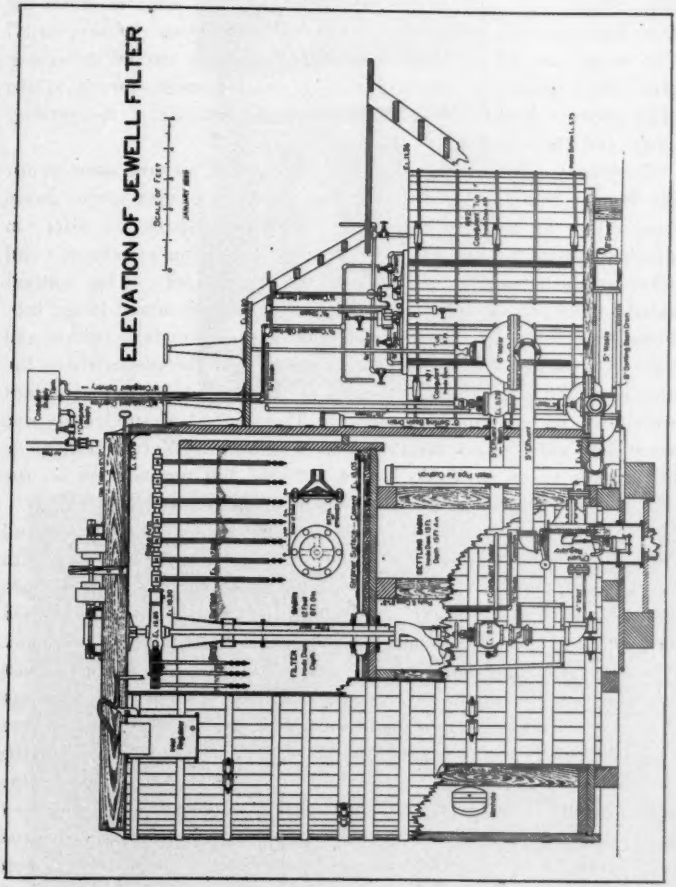

FIG. 7.

a settling basin in the bottom portion of an outside tank, and an open filter in a smaller tank placed within and above the former.

Settling Basin. The capacity of the basin was about 6 600 gallons, which was equal to the flow for thirty-five minutes when the filter was operated at the rate of 105 000 000 gallons per acre daily. The water was admitted to the basin through a curved deflecting pipe, which gave it a whirling motion as it passed upward to the filter above. Plate VII, Fig. 1, shows the interior of the settling basin and the supports for the filter above.

Coagulant. The preparation of the coagulant was the same as for the Warren Filter. The solution was lifted by a small steam pump from either of the two tubs to a small tank above the filter, in which a constant head was maintained by pumping an excess, and allowing the surplus to run back to the original tub. This method aided somewhat, also, towards keeping the solution mixed in the tub. From the tank the solution passed through a standard orifice and pipe to the settling basin, which it entered near the place where the applied water passed in. Changes in the amount of the coagulant were made by changing the orifices. This method of application was somewhat more exact than that used with the Warren Filter, as the figures given in Table No. 4 indicate, but incrustation on the edges of the orifice changed the area and thus caused errors.

Filter. The filter proper was placed above the settling basin and contained 4.8 feet in depth of round grained yellow beach sand, with an area of 113 square feet. Different sizes of sand were introduced by the owners from time to time. The uniformity coefficient varied from 1.3 to 1.7, and the effective size from 0.33 mm. to 0.47 mm. The water from the settling basin passed up through a central well and overflowed over the sand surface. After passing down through the sand the filtered water was collected in 443 screens, which were clamped over openings in the collecting pipes. The holes in the screens were 0.025 inch in diameter. Plate VII, Fig. 2, shows the screen heads on the pipes, together with the surrounding sand over a portion of the bed. These pipes drained to collecting conduits which entered the five-inch effluent pipe leading to the outside. Just outside the filter there was placed a cross connection which allowed water to pass either through the effluent meter and controller to a tank under the floor, or to the sewer, and, also, gave a chance to introduce wash-water in a reverse direction to cleanse the filter.

Controller. The principle of this device was as follows: It was

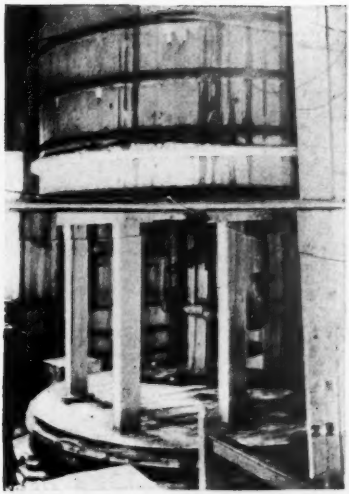

FIG. 1.—JEWELL FILTER. INTERIOR OF SETTLING BASIN.

FIG. 2.—JEWELL FILTER. SCREEN HEADS ON COLLECTING SYSTEM.

endeavored to maintain a constant head upon an orifice plate, placed in the bottom, by allowing such water as rose above a certain level to flow over into a cup. This cup was attached to a horizontal arm, the inner end of which operated a butterfly valve in the pipe, which discharged directly over this orifice. A view of this controller is given in Plate VIII, Fig. 1. The efficiency of this device was tested from time to time, and the variations of the flow, as shown by representative tests, are given in Table No. 5, page 167. In this connection, however, reference should be made to a new form of controller recently devised for this use, which has been stated to give satisfactory results.*

Washing. This work was done in the same general manner as with the Warren Filter; the dirty water in this case, however, overflowed in the annular space between the inner and outer tanks and thus away to the sewer. The agitating device, also, was somewhat different. There were two sets of arms and rakes, the larger ones being four feet long and fastened to arms reaching from the center across the filter bed, and placed 180 degrees apart. The shorter arms had only three rakes, were placed at right angles to the others, and stirred the sand close to the central well, which was not disturbed by the rakes on the longer arms. The rakes lay upon the sand of the filter when it was in operation, but when the power was applied in the proper direction, the arms started to revolve and forced the rakes to a vertical position and down into the sand. As the operation of washing was discontinued, the arms were made to revolve in the opposite direction, and the rakes pulled out on top of the bed again in a position nearly horizontal. The device made about seven turns per minute. Plate VIII, Fig. 2, shows the rakes nearly pulled out to the surface of the sand.

At certain times, instead of washing the filter bed, recourse was had to running the rakes around the bed in the direction opposite to that when washing, the water being still upon the surface. This method made furrows about two inches deep in the sand, and was called "trailing." When the bed was new or had recently been thoroughly cleansed by the boiling solution of soda ash, this method was quite effective, for once or twice after a washing, to restore the head lost, and for lengthening thus the time between washings; but at other times its benefit was not so evident.

*See paper by E. B. Weston, C.E., on "Mechanical Filtration," JOURNAL N. E. WATER WORKS ASSOCIATION, June, 1900, p. 343.

MECHANICAL FILTERS IN GENERAL.

Effect of Washing. An interesting factor in mechanical filtration is the effect which cleansing the filter sand by washing has on the character of the effluent. The results in Table No. 6 have been deduced from observations taken at random under the natural conditions of the work of both filters to show this effect. In general, the

TABLE NO. 6.— BACTERIAL EFFICIENCY OF MECHANICAL FILTERS BEFORE AND AFTER WASHING.

Calendar Date, 1898.	Name of Filter.	Average Bacteria per Cubic Centimeter in Effluent.				
		For Twenty-four Hours.	For One Hour before Washing.		For Twenty Minutes after Washing.	
		Number.	Number.	Per Cent. of Average for Twenty-four Hours.	Number.	Per Cent. of Average for Twenty-four Hours.
March 31	Warren	69	32	46	326	473
April 1	"	69	54	78	271	393
" 1	"	220	294	134	387	176
" 2	"	220	126	57	444	202
" 14	"	79	73	92	160	203
" 19	Jewell	96	55	57	338	352
" 20	Warren	32	14	44	233	729
" 20	Jewell	96	59	61	329	353
" 21	Warren	6	4	67	38	633
" 23	"	15	8	53	52	347
" 24	"	15	51	340	47	313
May 3	Jewell	36	29	81	175	486
" 6	"	28	6	21	205	732
June 2	Warren	105	79	75	516	491
" 2	"	100	60	60	469	469
" 6	"	17	6	35	21	124
August 12	"	165	11	7	1 180	715
" 13	"	165	166	101	549	333
Average,	—	85	63	74	319	375

number of bacteria was about five times as many immediately after washing as before, and quite often a greater turbidity of the effluent was noticeable. It was observed that under normal conditions, that is, with applied water of about the average muddiness, and with the same amount of coagulant used directly after washing as was ordi-

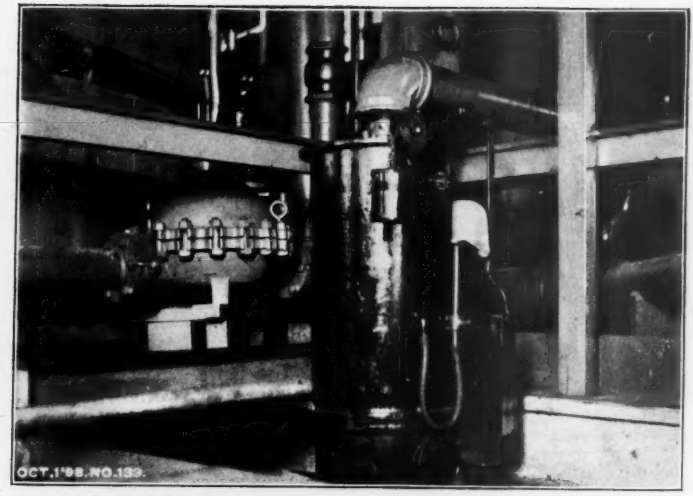

FIG 1.—JEWELL FILTER. CONTROLLER.

FIG. 2.—JEWELL FILTER. AGITATOR.

narily used to secure good results, this poor condition of the effluent extended over a period of about twenty minutes. If large quantities of coagulant were used directly after washing, — that is, considerably more than the average amount necessary for good results with the given condition of the water, — these higher numbers of bacteria would obtain for a short time only, say five or ten minutes, and then to a much less degree.

Effects of Using Different Quantities of Coagulant. During the months of May and June, 1897, special experiments were made to determine the effect of using large quantities of coagulant, and none at all.*

In general, after using a normal amount of coagulant, the effect of not using any was apparent by a somewhat turbid effluent about forty-five minutes after shutting off the supply of coagulant. In two hours the number of bacteria was from one half to about the same number as in the applied water, and the effluent was very much the same in appearance. The time needed for a filter to recover itself, after operation without coagulant, by using a large amount (in this particular case 2.75 grains per gallon) was the same, or about two hours.

Whirling Motion. It has been brought out by Mr. E. B. Weston in his very interesting paper on "Mechanical Filtration," presented

TABLE NO. 7.

Effect of Whirling Motion upon Settling with Coagulation.

	Bacteria per Cubic Centimeter.		
		Settled Water.	
Month, 1898.	Applied Water.	Warren.	Jewell.
February	9 430	7 130	7 190
March	11 750	6 160	5 780
April	5 000	3 360	3 620
July	16 800	10 900	10 900
August	15 100	7 550	7 780
Averages	11 600	7 020	7 050
	Amount of Suspended Matter. (Parts per 100 000.)		
Date, 1898.			
August 15	3.9	3.6	2.8
August 29	2.4	0.6	0.8
Averages	3.1	2.1	1.8
Ratio of capacity of settling basin to daily quantity	—	.0359	.0244

*For details see Report of Filtration Commission, pp. 170, 171.

TABLE NO. 8. — AVERAGE DAILY RESULTS OF MECHANICAL FILTERS, BY MONTHS.

MONTHS, 1898.	Hours in Operation per Day.		Rate of Filtration in Million Gallons per Acre Daily.		Ratio of Washing Time to Operating Time in Percentage.		Per Cent. of Filtrate used in Washing.		Sulphate of Alumina. — Grains per Gallon.		Turbidity.			Bacteria per Cubic Centimeter.			Percentage of Bacteria Removed.	
											Applied	Effluents.		Applied	Effluents.			
	War-ren.	Jew-ell.	War-ren.	Jew-ell.	War-ren.	Jew-ell.	War-ren.	Jew-ell.	War-ren.	Jew-ell.	Water.	War-ren.	Jew-ell.	Water.	War ren.	Jew-ell.	War-ren.	Jew-ell.
January	10.1	8.1	117	85	2.3	3.4	4.8	8.8	1.19	0.72	{ 0.29 W 0.16 J	.001	—	{ 19 550 W 12 950 J	950	1 980	95.14	84.70
February . . .	21.3	20.7	104	98	1.4	2.1	3.8	6.1	0.70	0.56	0.15	.005	.004	9 430	238	638	97.48	93.23
March	22.3	22.2	108	106	0.9	1.2	3.5	4.3	1.81	1.07	0.30	.001	.001	11 750	164	208	98.60	98.23
April	23.0	22.9	122	106	0.7	0.7	2.6	2.8	0.86	0.54	0.08	.001	.000	5 000	78	159	98.44	96.83
May	23.6	23.2	115	106	0.8	1.2	2.6	4.6	1.55	1.00	0.19	.015	.000	10 800	630	150	94.20	98.61
June	23.3	22.8	103	106	1.0	1.4	3.9	5.4	1.36	1.18	0.19	.001	.008	11 100	115	1 450	98.96	86.90
July	19.5	22.2	119	103	1.4	1.8	5.1	7.6	1.46	1.31	0.11	.003	.008	16 800	320	345	98.10	97.95
August	23.2	22.9	137	103	1.5	1.5	5.1	6.3	1.76	1.35	0.36	.016	.000	15 100	290	260	98.08	98.28
Average, 6 months,	22.1	22.3	115	104	1.1	1.4	4.0	5.3	1.32	0.97	0.20	.004	.002	11 500	201	293	98.25	97.45

NOTE. — During the month of May with the Warren filter and the month of June with the Jewell filter, special experiments with varying quantities of coagulant were made. Averages do not include these months, nor the month of January.

to this Association January 10, 1900,* that, by having a whirling motion of the water at the entrance to the settling basin of the Jewell Filter, there is a considerable gain in the precipitation of suspended and organic matter. So far as the writer knows, there is presented in the preceding table, No. 7, for the first time, actual numerical data upon results with the same water under conditions of whirling and without. The quantities of coagulant added to the two filters are not sufficiently different to seriously affect the results and conclusions, but are, in general, larger for the Warren. It will be seen that the effect of the coagulation in each settling basin is about the same, although the Warren has fifty per cent. greater capacity in proportion to the daily quantity. The water in this settling basin takes a somewhat winding but quiet course, while in the Jewell it is given a rapid whirling motion.

The quantitative and bacterial results obtained with the mechanical filters, tabulated by months, are given in Table No. 8. The

TABLE NO. 9. — AVERAGE RESULTS OF CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM THE ALLEGHENY RIVER, AND SAND AND MECHANICAL FILTERS, DURING THE SEVEN MONTHS ENDING AUGUST 31, 1898.

(PARTS PER 100 000.)

CONSTITUENTS.	River Water.	Effluents.				Percentage of Constituents Removed.			
		Sand Filters.		Mechanical Filters.		Sand Filters.		Mechanical Filters.	
		No. 1.	No. 2.	Warren.	Jewell.	No. 1.	No. 2.	Warren.	Jewell.
Turbidity	—	0.010	0.012	0.000	0.001	—	—	—	—
Color	0.26	0.07	0.07	0.03	0.03	73	73	88	88
Nitrogen as									
Albuminoid Ammonia	0.0101	0.0054	0.0053	0.0047	0.0043	47	48	53	57
Free Ammonia	0.0020	0.0018	0.0018	0.0019	0.0018	10	10	5	10
Nitrites	0.0000	0.0000	0.0000	0.0000	0.0000	—	—	—	—
Nitrates	0.0568	0.0642	0.0549	0.0550	0.0520	–13	3	3	8
Chlorine	1.87	1.84	1.77	1.76	1.65	2	5	6	12
Total Solids	15.4	10.8	10.6	9.5	9.4	30	31	38	39
Suspended Matter	5.3	0.0	0.0	0.1	0.1	100	100	98	98
Total Hardness	3.21	4.31	4.33	2.96	2.89	–34	–35	8	10
Alkalinity	2.44	3.53	3.56	1.64	1.69	–45	–46	33	31
Sulphuric Acid	1.15	1.15	1.15	1.86	1.59	—	—	–62	–38

*JOURNAL, June, 1900, pp. 349, 358, 359.

averages of the chemical constituents of the applied water and of the effluents of the mechanical filters, also compared with those of the sand filters for the same seven months, are given in Table No. 9.

WORMS TILE FILTER.

The process of water purification by the Wormser System as tried at Pittsburgh was twofold: first, a preliminary treatment by the addition of chloride of iron and removal of some matter by passage through broken stone; and second, a filtration through the tiles.

Tiles. The tiles were made in Germany, and were composed of sand and broken glass baked in a mould. They were about thirty-nine inches square and four inches thick. In the center of each there was an open chamber of about one-half cubic foot capacity, into which the filtered water passed. On Plate IX, Fig. 1, there is a view of a tile ready to be placed in the tank, showing the method of making the pipe connection by gasket to the hole leading to the interior of the tile.

Washing. The tiles were washed by a reverse current of filtered water, with a head of 19.5 feet above the center of the tiles. Care was taken in washing the tile to let on the wash-water pressure slowly and maintain the flow uniformly. Nevertheless, as soon as the tiles became sufficiently clogged to begin to produce a good effluent, they all became broken one after another when being washed. Plate IX, Fig. 2, shows the line of breakage on two of the tiles, and also an idea of the interior construction.

Results. In Table No. 10 are presented the average bacterial results by months, obtained with this system of filtration. It will be seen that the tiles themselves do not appear to have materially reduced the number of bacteria from those in the water flowing from the settling tanks, which had been treated with coagulant.

BOILER EXPERIMENTS.

The use of water for industrial purposes is an important consideration in Pittsburgh, or, indeed, in any large manufacturing city. It was considered advisable to learn what the effect would be of clarifying and filtering the Allegheny River water prior to its use in boilers.

Three new 25 H. P. boilers were kindly loaned by the Oil Well Supply Co., for the purpose of an experiment in this line. A view of these boilers in position is given on Plate X, Fig. 1. Boiler

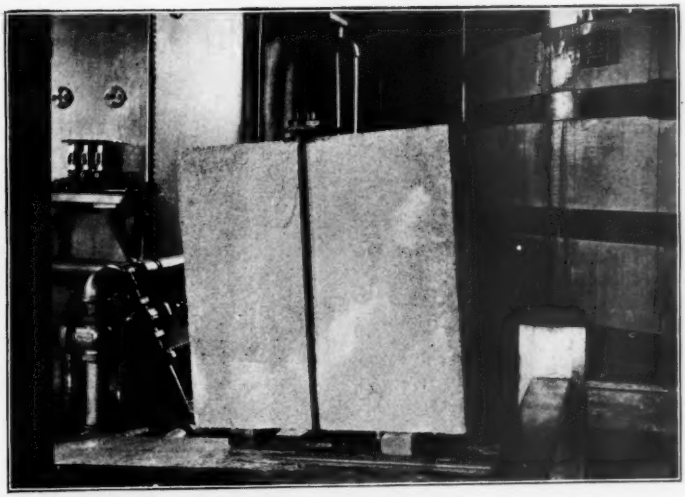

FIG. 1. — WORMS TILE, WITH FITTINGS.

FIG. 2. — WORMS TILES, BROKEN IN SERVICE.

TABLE NO. 10.—AVERAGE BACTERIAL RESULTS WITH WORMS TILE FILTER.

Month, 1897-98.	Bacteria per Cubic Centimeter.									Percentage of Bacteria Removed.							
	Applied Water.	Settled Water.	Effluents.			Settled Water.	Effluents.			Settled Water.	Effluents.			Settled Water.	Effluents.		
		Tank No. 3.	Tile A.	Tile B.	Tile C.	Tank No. 4.	Tile D.	Tile E.	Tile F.	Tank No. 3.	Tile A.	Tile B.	Tile C.	Tank No. 4.	Tile D.	Tile E.	Tile F.
1st Test.																	
December . .	14 430	9 160	8 010	5 280	5 965	12 260	4 990	5 430	4 930	36.60	44.50	63.40	58.70	15.00	65.40	62.30	65.90
January . . .	15 330	7 680	3 050	3 360	2 470	—	6 550	4 120	—	49.90	80.10	78.10	83.90	—	57.30	73.20	—
February . .	9 430	3 290	740	800	1 030	—	—	—	—	65.10	92.20	91.50	89.10	—	—	—	—
March . . .	11 750	4 790	460	630	790	—	—	—	—	59.20	96.00	94.60	93.30	—	—	—	—
2d Test.																	
June	12 000	340	690	470	500	410	510	470	470	97.20	94.30	96.10	95.80	96.60	95.70	96.10	96.10
July	16 800	920	310	400	370	1 010	980	960	590	94.50	98.20	97.60	97.80	94.00	94.20	94.30	96.50
August . . .	16 900	340	100	120	70	360	340	320	110	98.00	99.40	99.30	99.60	97.80	98.00	98.10	99.40
1st Test Average,	12 730	6 230	3 070	2 520	2 560	—	—	—	—	51.10	75.90	80.20	79.90	—	—	—	—
2d Test Average,	15 200	530	360	330	310	600	610	580	390	96.50	97.60	97.80	97.90	96.10	96.00	96.10	97.40

Note.—Coagulant was applied to the water in Tank No. 3 all the time; but to the water in Tank No. 4 during June, July, and August only.

No. 1 was supplied with the effluent from the sand filters, No. 2 with the effluent from the mechanical filters, and No. 3 with the unclarified river water. After these boilers had been in service for about two and one-half months, they were blown off hot; samples of scale were collected, and an examination was made of the interior of each. The results of the chemical analyses of the scales are given in the following table, No. 11: —

TABLE No. 11.

Results of Chemical Analyses of Boiler Scales.

Samples Collected September 17, 1898.

Items.	Boiler No. 1.	Boiler No. 2.	Boiler No. 3.
	Parts by Weight.		
Calcium carbonate	53.21	27.42	3.34
Calcium sulphate	13.06	53.88	0.75
Magnesium carbonate	25.33	12.58	11.06
Sodium chloride	5.74	1.64	0.39
Iron and aluminum oxides	1.42	3.64	16.66
Insoluble matter	1.24	0.84	67.80
Totals	100.00	100.00	100.00

Scale. It will be seen that scale from the boilers using the effluent from the sand filters was composed largely of the carbonates of calcium and magnesium, which are not as troublesome as sulphates. It was said that, by cooling down slowly, the formation of this kind of scale could have been in a measure prevented. It will be noticed that the scale from the boiler using the effluent from the mechanical filters was composed largely of sulphate of calcium, which is what would be expected from the chemical action caused by the addition of sulphate of alumina to the water. The scale upon the third boiler was soft and composed largely of mud and insoluble matter; material which could have been largely removed by judicious blowing out from time to time.

The statement of the practical boiler mechanic, who examined the interiors after the experimental use, was that boiler No. 3 was in the best condition. This problem must be considered far from settled, however, on the basis of such a limited experiment.

CHEMICAL ANALYSES.

The following pages contain tables giving a statement of the average chemical analyses by months of the samples of river water and the various effluents.

FIG. 1. — EXPERIMENTAL BOILERS.

TABLE NO. 12A.—AVERAGE RESULTS BY MONTHS OF CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM ALLEGHENY RIVER AT BRILLIANT.

(PARTS PER 100 000.)

YEAR.	MONTH.	COLOR.	NITROGEN AS				CHLORINE.	RESIDUE ON EVAPORATION.		TOTAL HARDNESS.	ALKALINITY.	SULPHURIC ACID.	IRON.
			ALBUMINOID AMMONIA.	FREE AMMONIA.	NITRITES.	NITRATES.		TOTAL.	SUSPENDED.				
1897	June	—	0.0137	0.0006	0.0000	0.0175	2.40	14.1	—	7.65	—	1.40	—
,,	July	—	0.0307	0.0034	0.0001	0.0106	3.13	26.9	11.1	5.84	6.08	1.33	0.184
,,	August	—	0.0210	0.0023	0.0000	0.1050	2.03	9.0	1.0	5.41	4.05	0.86	0.007
,,	September	0.37	0.0133	0.0019	0.0000	0.0650	2.70	13.1	—	5.03	4.63	1.82	0.063
,,	October	0.23	0.0120	0.0017	0.0000	0.0550	3.81	17.7	—	5.49	5.09	2.31	0.046
,,	November	0.29	0.0152	0.0019	0.0000	0.0700	3.15	19.7	2.0	3.89	3.51	2.47	0.095
,,	December	0.30	0.0111	0.0015	0.0000	0.1075	2.11	23.7	10.7	2.24	1.72	1.79	0.123
1898	January	0.28	0.0074	0.0016	0.0000	0.0885	1.53	15.3	4.8	2.09	1.48	1.43	0.112
,,	February	0.21	0.0099	0.0020	0.0000	0.1425	1.46	11.9	1.4	2.59	1.73	1.24	0.059
,,	March	0.24	0.0076	0.0015	0.0000	0.0487	1.29	14.0	4.3	2.72	1.75	1.18	0.040
,,	April	0.22	0.0077	0.0018	0.0000	0.0458	1.36	9.4	0.2	2.29	1.83	1.08	0.041
,,	May	0.30	0.0164	0.0015	0.0000	0.0180	1.66	20.7	11.9	2.80	2.13	1.00	0.033
,,	June	0.25	0.0085	0.0019	0.0000	0.0300	2.42	19.1	9.0	3.51	3.10	1.04	0.010
,,	July	0.27	0.0100	0.0027	0.0000	0.0694	2.47	13.1	1.4	4.53	3.41	1.55	0.020
,,	August	0.31	0.0103	0.0024	0.0000	0.0435	2.42	19.5	8.8	3.99	3.15	0.93	0.020
Average, 15 months		0.27	0.0130	0.0019	0.0000	0.0611	2.26	16.5	5.4	4.00	3.12	1.43	0.061
Average, August, 1897, to August, 1898		0.27	0.0116	0.0019	0.0000	0.0684	2.19	15.9	5.0	3.58	2.89	1.44	0.051
Average, January, 1898, to August, 1898		0.26	0.0097	0.0019	0.0000	0.0608	1.83	15.4	5.2	3.06	2.32	1.18	.042

TABLE NO. 12B.—AVERAGE RESULTS BY MONTHS OF CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM GATE CHAMBER.

(PARTS PER 100 000.)

YEAR.	MONTH.	COLOR.	NITROGEN AS				CHLORINE.	RESIDUE ON EVAPORATION.		TOTAL HARDNESS.	ALKALINITY.	SULPHURIC ACID.	IRON.
			ALBUMINOID AMMONIA.	FREE AMMONIA.	NITRITES.	NITRATES.		TOTAL.	SUSPENDED.				
1897 .	July . . .	—	0.0260	0.0020	0.0001	0.1481	1.12	15.0	6.0	4.39	4.71	1.07	0.185
,, .	August . .	0.45	0.0222	0.0015	0.0000	0.0763	1.63	14.1	4.3	5.44	5.13	1.10	0.177
,, .	September .	0.32	0.0128	0.0017	0.0000	0.0471	2.47	13.3	—	5.75	4.95	1.86	0.044
,, .	October . .	0.26	0.0141	0.0018	0.0000	0.0670	3.41	17.2	—	5.30	4.92	2.47	0.052
,, .	November .	0.29	0.0148	0.0017	0.0000	0.0557	3.13	21.3	3.6	4.15	3.73	2.48	0.114
,, .	December .	0.30	0.0085	0.0014	0.0000	0.1012	1.73	15.8	3.5	1.84	1.44	1.63	0.125
1898 .	January . .	0.26	0.0070	0.0012	0.0000	0.0915	1.37	14.4	4.6	2.11	1.60	1.37	0.118
,, .	February .	0.24	0.0106	0.0014	0.0000	0.1400	1.29	12.7	2.4	2.80	1.86	1.15	0.116
,, .	March . . .	0.23	0.0102	0.0030	0.0000	0.0495	1.18	22.2	12.0	2.88	1.91	1.66	0.064
,, .	April . . .	0.23	0.0083	0.0021	0.0000	0.0544	1.29	9.0	0.1	2.75	2.11	1.14	0.040
,, .	May . . .	0.29	0.0116	0.0011	0.0000	0.0300	1.39	11.0	2.7	2.79	2.19	0.74	0.042
,, .	June . . .	0.25	0.0089	0.0022	0.0000	0.0394	2.16	17.8	7.7	3.34	3.15	1.13	0.013
,, .	July . . .	0.26	0.0098	0.0028	0.0000	0.0694	2.44	12.7	0.9	4.56	3.47	1.36	0.022
,, .	August . .	0.29	0.0107	0.0025	0.0000	0.0450	2.35	19.7	8.6	4.03	3.16	1.01	0.016
Average, excluding July, 1897 . . .		0.28	0.0115	0.0019	0.0000	0.0667	1.99	15.5	4.6	3.67	3.05	1.47	0.073

TABLE NO. 12c.—AVERAGE RESULTS BY MONTHS OF CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM SETTLING BASIN.

(PARTS PER 100 000.)

YEAR.	MONTH.	COLOR.	NITROGEN AS				CHLORINE.	RESIDUE ON EVAPORATION.		TOTAL HARDNESS.	ALKALINITY.	SULPHURIC ACID.	IRON.
			Albuminoid Ammonia.	Free Ammonia.	Nitrites.	Nitrates.		Total.	Suspended.				
1897	July	—	0.0234	0.0031	0.0000	0.1075	1.70	14.0	5.5	4.73	6.05	1.44	0.147
,,	August	0.45	0.0204	0.0015	0.0000	0.0675	1.65	11.4	1.3	5.71	5.12	1.10	0.088
,,	September	0.32	0.0131	0.0019	0.0000	0.0408	2.63	13.9	—	5.47	4.91	1.84	0.041
,,	October	0.24	0.0133	0.0017	0.0000	0.0703	3.26	17.0	—	5.13	4.86	2.36	0.048
,,	November	0.26	0.0147	0.0021	0.0000	0.0600	3.58	20.4	2.2	4.42	4.02	2.16	0.119
,,	December	0.29	0.0089	0.0014	0.0000	0.0806	1.84	11.9	0.4	2.31	1.89	1.26	0.102
1898	January	0.22	0.0061	0.0014	0.0000	0.1069	1.47	12.0	1.7	2.06	1.67	1.51	0.126
,,	February	0.24	0.0101	0.0017	0.0000	0.1500	1.38	11.1	0.3	2.94	1.91	1.14	0.088
,,	March	0.22	0.0085	0.0014	0.0000	0.0450	1.24	10.4	0.4	2.81	1.87	1.00	0.038
,,	April	0.20	0.0084	0.0026	0.0000	0.0431	1.45	9.1	0.1	2.69	2.07	1.25	0.045
,,	May	0.27	0.0088	0.0012	0.0000	0.0255	1.30	9.3	1.2	2.58	2.18	0.79	0.040
,,	June	0.23	0.0083	0.0020	0.0000	0.0300	2.12	12.2	2.3	3.27	2.96	0.95	0.014
,,	July	0.24	0.0095	0.0026	0.0000	0.0637	2.67	14.6	2.2	4.61	3.30	1.55	0.021
,,	August	0.29	0.0104	0.0024	0.0000	0.0495	2.45	16.7	5.4	3.97	3.08	1.02	0.015
Average, excluding July, 1897		0.27	0.0105	0.0018	0.0000	0.0641	2.08	13.1	1.6	3.69	3.07	1.38	0.060

TABLE NO. 12D.—AVERAGE RESULTS BY MONTHS OF CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM SAND FILTER NO. 1.

(PARTS PER 100 000.)

YEAR.	MONTH.	COLOR.	NITROGEN AS				CHLORINE.	Residue on Evaporation.		TOTAL HARDNESS.	ALKALINITY.	SULPHURIC ACID.	IRON.
			Albuminoid Ammonia.	Free Ammonia.	Nitrites.	Nitrates.		Total.	Suspended.				
1897 .	July . . .	—	0.0184	0.0051	0.0001	0.1243	2.02	28.9	1.2	6.59	9.12	1.26	0.127
,, .	August . .	0.35	0.0100	0.0009	0.0001	0.0707	1.51	10.3	—	7.30	7.16	1.07	0.034
,, .	September .	0.06	0.0076	0.0014	0.0000	0.0548	2.43	13.8	—	6.52	6.07	1.91	0.006
,, .	October . .	0.00	0.0078	0.0017	0.0000	0.0816	3.12	17.4	—	5.99	5.60	2.52	0.006
,, .	November .	0.10	0.0097	0.0014	0.0000	0.0771	3.62	18.5	0.0	5.01	4.74	2.23	0.024
,, .	December .	0.02	0.0056	0.0015	0.0000	0.0937	1.90	11.7	0.0	3.26	2.81	1.36	0.031
1898 .	January . .	0.12	0.0049	0.0011	0.0000	0.1020	1.39	9.9	0.0	3.13	2.63	1.52	0.028
,, .	February .	0.10	0.0077	0.0013	0.0000	0.1625	1.44	10.9	0.0	3.25	2.68	1.22	0.028
,, .	March . .	0.00	0.0040	0.0016	0.0000	0.0525	1.23	9.5	0.0	3.59	2.74	1.05	0.016
,, .	April . . .	0.02	0.0050	0.0021	0.0000	0.0469	1.56	8.7	0.0	3.46	2.88	1.14	0.010
,, .	May . . .	0.09	0.0048	0.0010	0.0000	0.0270	1.31	8.3	0.0	4.12	3.30	0.86	0·012
,, .	June . . .	0.06	0.0057	0.0016	0.0000	0.0412	2.14	11.2	0.0	4.42	4.10	1.01	0.004
,, .	July . . .	0.09	0.0055	0.0023	0.0000	0.0731	2.60	14.2	0.0	5.97	4.67	1.66	0.005
,, .	August . .	0.12	0.0050	0.0022	0.0000	0.0465	2.56	12.5	0.0	5.36	4.37	1.12	0.004
Average, excluding July, 1897 . . .		0.09	0.0064	0.0015	0.0000	0.0715	2.06	12.1	0.0	4.72	4.13	1.44	0.016

TABLE NO. 12E.—AVERAGE RESULTS BY MONTHS OF CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM SAND FILTER NO. 2.

(PARTS PER 100 000.)

YEAR.	MONTH.	COLOR.	NITROGEN AS				CHLORINE.	RESIDUE ON EVAPORATION.		TOTAL HARDNESS.	ALKALINITY.	SULPHURIC ACID.	IRON.
			ALBUMINOID AMMONIA.	FREE AMMONIA.	NITRITES.	NITRATES.		TOTAL.	SUSPENDED.				
1897	July	—	0.0158	0.0059	0.0001	0.1158	1.90	23.9	4.4	7.25	22.15	1.99	0.130
,,	August	0.35	0.0101	0.0009	0.0000	0.0760	1.58	10.5	—	7.35	7.20	1.17	0.036
,,	September	0.06	0.0078	0.0015	0.0000	0.0533	2.40	13.8	—	6.63	6.07	2.01	0.004
,,	October	0.00	0.0082	0.0015	0.0000	0.0722	3.17	17.9	—	6.12	5.74	2.55	0.005
,,	November	0.09	0.0091	0.0015	0.0000	0.0761	3.35	18.4	0.0	5.68	5.33	2.27	0.023
,,	December	0.04	0.0064	0.0012	0.0000	0.0731	1.89	11.5	0.0	3.21	2.76	1.29	0.029
1898	January	0.11	0.0046	0.0012	0.0000	0.1050	1.42	10.7	0.0	3.47	2.84	1.48	0.025
,,	February	0.08	0.0073	0.0014	0.0000	0.1000	1.41	11.0	0.0	3.50	2.77	1.22	0.041
,,	March	0.02	0.0039	0.0017	0.0000	0.0550	1.24	9.4	0.0	3.81	3.07	1.04	0.026
,,	April	0.02	0.0046	0.0021	0.0000	0.0469	1.42	8.6	0.0	3.62	3.02	1.14	0.012
,,	May	0.10	0.0046	0.0011	0.0000	0.0255	1.25	8.2	0.0	3.81	3.32	0.74	0.011
,,	June	0.05	0.0060	0.0014	0.0000	0.0319	2.16	11.4	0.0	4.58	4.30	1.04	0.003
,,	July	0.06	0.0057	0.0024	0.0000	0.0769	2.37	13.5	0.0	5.77	4.39	1.54	0.004
,,	August	0.15	0.0049	0.0025	0.0000	0.0480	2.56	12.1	0.0	5.24	4.04	1.30	0.004
Average, excluding July, 1897		0.09	0.0064	0.0016	0.0000	0.0646	2.02	12.1	0.0	4.83	4.22	1.45	0.017

TABLE NO. 12F.—AVERAGE RESULTS BY MONTHS OF CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM MECHANICAL FILTERS.

(PARTS PER 100 000.)

YEAR.	MONTH.	COLOR.	NITROGEN AS				CHLORINE.	RESIDUE ON EVAPORATION.		TOTAL HARDNESS.	ALKALINITY.	SULPHURIC ACID.	IRON.
			ALBUMINOID AMMONIA.	FREE AMMONIA.	NITRITES.	NITRATES.		TOTAL.	SUSPENDED.				
			WARREN FILTER.										
1898 .	February . .	0.04	0.0055	0.0020	0.0000	0.0875	1.34	7.7	0.0	2.04	1.23	1.53	0.009
„ .	March . . .	0.00	0.0039	0.0015	0.0000	0.0487	1.29	7.8	0.0	1.94	1.15	2.00	0.007
„ .	April . . .	0.01	0.0041	0.0016	0.0000	0.0467	1.19	7.9	0.0	1.86	1.31	1.47	0.005
„ .	May . . .	0.05	0.0052	0.0014	0.0000	0.0285	1.38	8.2	0.0	2.66	1.48	1.44	0.014
„ .	June . . .	0.06	0.0049	0.0015	0.0000	0.0319	2.11	10.2	0.0	4.06	2.10	1.93	0.003
„ .	July . . .	0.00	0.0045	0.0018	0.0000	0.0700	2.32	11.5	0.0	3.83	2.42	2.02	0.002
„ .	August . .	0.05	0.0051	0.0032	0.0000	0.0450	2.34	11.7	0.6	4.02	1.65	2.19	0.002
	Average . .	0.03	0.0047	0.0019	0.0000	0.0512	1.71	9.3	0.1	2.92	1.62	1.80	0.006
			JEWELL FILTER.										
1898 .	February . .	0.08	0.0038	0.0017	0.0000	0.0862	1.31	7.8	0.0	2.27	1.41	1.38	0.010
„ .	March . . .	0.00	0.0035	0.0015	0.0000	0.0534	1.17	7.3	0.0	2.09	1.21	1.59	0.006
„ .	April . . .	0.00	0.0042	0.0018	0.0000	0.0475	1.22	7.8	0.0	1.93	1.44	1.21	0.008
„ .	May . . .	0.01	0.0040	0.0013	0.0000	0.0214	1.36	8.1	0.0	2.62	1.49	1.42	0.004
„ .	June . . .	0.05	0.0050	0.0021	0.0000	0.0319	2.03	10.4	0.0	3.83	1.91	2.11	0.003
„ .	July . . .	0.05	0.0047	0.0017	0.0000	0.0600	2.40	13.6	0.0	4.57	2.48	2.23	0.003
„ .	August . .	0.04	0.0058	0.0027	0.0000	0.0435	2.45	11.6	0.5	3.87	2.10	1.72	0.002
	Average . .	0.03	0.0044	0.0018	0.0000	0.0491	1.71	9.5	0.1	3.03	1.72	1.67	0.005

DISCUSSION.

THE PRESIDENT. I would like to call upon Mr. Rudolph Hering, C.E., of New York, to give us a little of his experience and observation in connection with sand filters.

MR. RUDOLPH HERING. Mr. Chairman, ladies and gentlemen: This last summer the American Society of Civil Engineers held their annual convention in London, and among the subjects which were set down for discussion was that of the filtration of public water supplies. The reason for introducing this subject was to get the opinion, not only of American engineers, but also of European engineers, on the several methods which are now used to purify water supplied for public use. The meeting was well attended, and we had quite a number of discussions, particularly from European engineers. I mention this to call your attention to the fact that this discussion probably forms in a small compass the fullest exposition of authoritative European views that we have up to this time. The papers will be printed in the next volumes of the Transactions of the Society.

The question was brought up for discussion mainly because there is a difference of opinion as to the relative merits of slow or sand filtration, and what we sometimes call rapid filtration, or, more commonly, the mechanical system of filtration. Sand filtration is a slow process, where only from five to ten feet of water, measured vertically, pass through the sand in a day, while in the mechanical filters from 200 to 300 feet of water pass through in a day; therefore the terms "slow" and "rapid" are very characteristic.

The mechanical filters, as you know, are an American production; they have been developed here. The European engineers do not know much about them yet, and have therefore not introduced them for public supplies. It was interesting to hear their opinions on the subject. There were but very few advocates of the mechanical filters, as we might expect, the majority favoring the slow filters, which are the common filters of Europe.

The first slow filter was introduced, seventy years ago, by one of the London water companies, and, therefore, our experience has been quite long. The works, however, were operated more on an empirical than on a scientific basis. We, that is, the Americans, through the Massachusetts State Board of Health, have developed the system of slow filtration more scientifically, and since then much better re-

sults have been obtained in Europe with their filters by making use of the results of our experiments.

While in Europe this summer I visited a number of these filtration plants, and was very much pleased with their results. We are not yet as fully developed in that direction. We have but a few slow filters, although a large number of mechanical filters; yet we are more and more appreciating the necessity of water filtration. As we have new conditions which were not presented in Europe, it has been necessary for us to make extensive experiments, and you probably all know of the careful investigations which were made in Louisville and in Cincinnati, as well as those in Pittsburgh, of which Mr. Knowles has just given us such an excellent description; and at the present time similar experiments are being made in Philadelphia, and have been inaugurated also at New Orleans. These results will give a splendid exposition of the characteristics of very different waters, and have already made it evident that the results found in Europe could not be indiscriminately applied here. When these experiments have all been completed, the water-works engineer will have a very good foundation for his future work in this country.

The European engineers are favored in one particular way, namely, that they continue, you might say, as permanent officers to conduct their works. In our country, as you know, such positions are not so permanent, and, through our political changes, the officers are apt to be disturbed, which hampers them in their efforts to establish the best possible works. In Europe they are continually planning for the future, and for that reason they are in a much better position to attain those excellent results that they have reached than we are. I think this fact should be more generally recognized, and we as engineers should not get the blame that sometimes rests on the profession, because the conditions of our present system of municipal government are responsible for most of the failures. This, by the way, is a subject worth the serious attention of all who are interested in municipal administration. The terms of office of professional officials should be materially lengthened, taken out of politics, and based on merit alone.

The works in Europe are operated with a much smaller per capita water consumption than here, as you know, and that is another point in their favor. They can do better, because they have less to do. The problem with us sometimes becomes enormous. Take, for instance, the city of Philadelphia. There we had to estimate last year

for an amount of water to be filtered equal to the consumption of London of to-day, and in New York the recent propositions are to double even that quantity. So you see the enormity of the questions with which we have to deal, compared with those dealt with in Europe, and for that reason judgment should be a little easy regarding the results accomplished in America. We should not be blamed for at present going ahead slower than they do in Europe, because also the problems presented to us are greater.

I shall say just a few words regarding the larger cities of Europe, and what they are doing to keep their water pure. Last evening I said that Vienna, Glasgow, and Paris, and perhaps one or two more cities, furnished raw water to their inhabitants. All the other cities furnish either ground water or filtered water. In this country it is almost impossible to furnish a large city with ground water, because the consumption is so great, be it on account of waste or greater use of water. Ground waters are, of course, excellent in quality. Such cities as Munich and Dresden, with three or four hundred thousand people, are supplied with ground water, and they have all that they need. The city of Berlin, which, I think, has now a population of a million and a quarter, has filtered water; London has partly filtered water, partly ground water from the chalk wells.

In Hamburg they used raw water from the river Elbe until a few years ago. You probably remember the cholera epidemic which occurred there in 1892. That was due wholly to the pollution of the drinking water, which was pumped from the river directly into the distribution system, and caused that dreadful epidemic. Immediately adjoining Hamburg is the city of Altona, so close that you do not know when you pass from one city into the other, yet their water supplies are entirely distinct. During the cholera epidemic, as you probably know, the cases were limited to Hamburg, although Altona used the water from the same river, with all the Hamburg sewage in it, but filtered it, and, therefore, supplied it to the inhabitants in a purer condition.

Hamburg thereupon immediately began to hurry the construction of its filtration works, and now that city is getting very pure water. The bacteria are reduced in number about ninety-nine per cent. The German government does not think this percentage method of indicating the removal of bacteria a proper one; and, I think, if we reason about it a little, we must all agree that it is wrong. Their specification is that not more than one hundred bacteria shall remain in

a cubic centimeter of water. We have just seen that in the Pittsburgh experiments there were two hundred or three hundred left, notwithstanding ninety-nine per cent. of the bacteria had been removed, so that some of the Pittsburgh effluent would not be good enough, according to the German government rules, and yet, according to our rules, it is sufficiently good.

Another phenomenon which was very noticeable in Hamburg after the introduction of the filtered water was that the typhoid-fever rate immediately dropped from, I think, 20 or 25 per 1 000 down to 3, 4, or 5 per 1 000, which is a very common result after the introduction of filters. We have seen the same thing at Albany, where the largest filter plant in our country exists. These results, and the knowledge we have that the pollution of a water supply, even by a single person, may cause an epidemic of typhoid fever, as in the case of Plymouth, Pa., certainly must cause us all to desire to filter our domestic water supply. Our city governments will, no doubt, eventually see fit to provide the money for such a purpose, and I think it is our duty as engineers to advise them as to the facts and responsibilities in this matter.

The city of Moscow in Russia was not satisfied with the slow filtration process, because it has sometimes yielded water that is not perfectly clear. It, therefore, sent its engineer over here a few years ago to examine into the merits of the rapid or mechanical filters. If you have fine particles of clay suspended in water, ordinary sand filtration will not clear it. The little particles of clay are much smaller than bacteria, and they go through the filter, even though the bacteria may be retained. By the necessary use of alum and consequent coagulation, in the mechanical filters we can keep these fine particles of clay from getting through; and the engineer of Moscow returned to Europe very much in favor of mechanical filters. However, he is now making a series of experiments in order to find out which of the two systems is really the more satisfactory for his conditions, the first series of such experiments to be made in Europe.

The river waters that carry this very fine clay, such as we have in the Ohio and other rivers, cannot always be clarified by slow filtration. Sometimes a previous coagulation by alum will be necessary also with this system.

In Berlin, St. Petersburg, and Warsaw they have also excellent systems of water filtration.

I thank you, gentlemen, for listening to me so patiently.

UNIFORMITY IN MUNICIPAL REPORTS.

BY M. N. BAKER, ASSOCIATE EDITOR, ENGINEERING NEWS.

[*Presented September 19, 1900.*]

Mr. President and Members of the Association: There has been of late a strong and quite widespread movement, as you know, towards securing greater uniformity in municipal accounts and reports. The later and present movement may perhaps be said to have originated through the action of the American Society of Civil Engineers at its annual meeting a year ago, when it was decided to appoint a committee to urge upon the Census Bureau the collection and incorporation of complete municipal statistics in the census returns. Later on the American Society of Municipal Improvements appointed a similar committee to coöperate with the first.

As the work of these two committees progressed, it was found to be impossible for the Census Bureau to do anything whatever in relation to the compilation of municipal statistics prior to 1902, or, in other words, until it had completed its main investigations, the act under which the present census has been taken containing that limitation. Just what will be done after 1902 is as yet unknown, as the Census Bureau is confining its work entirely to the main enumerations, being engaged now on the population, as you know, and having begun also on some of the other main inquiries relating to manufactures and agriculture.

As the agitation on this general subject progressed, one association after another took up the work, each perhaps from a little different point of view; and altogether there have been ten or a dozen national associations of different characters, but all having to do more or less directly with municipal work, that have appointed, or are proposing to appoint at their next meetings, committees on uniform municipal accounts and reports. The general idea which is animating these societies in the appointment of these committees is to have them empowered to secure coöperation between the different societies.

The need for just such coöperation as this is well illustrated by the fact that each of three different societies that aim to secure greater

uniformity in the matter of water-works reports has separately adopted a different schedule, which is not just the very best possible way to secure uniformity, although it is better to have three different schemes than as many as there are water works in the country.

It is very desirable that the three societies in question should have a uniform system of summarizing their statistics in their annual reports. The New England Water Works Association and the American Water Works Association each adopted, at about the same time, a scheme for uniform reports, but the scheme adopted by the American Association has never been put in use by any water works, so far as I know, while the New England schedule has been adopted by a few works. I am glad to see by the last number of the JOURNAL that the number of works adopting it has increased since the last tabulation of the statistics, so that there are now twenty-eight different works that are using this schedule. That, of course, is a small number compared with those represented in the membership of this Association, and much smaller yet when compared with the total number of water works in the country.

The other organization which has worked along this line is the American Society of Municipal Improvements, which, through its committee on municipal data, adopted another schedule for the annual reports a year ago. The original scheme was submitted to the Association two years ago, but so far as I can learn none of the members of that Association has as yet used the schedule formulated by the committee on municipal data. At the meeting of the American Society of Municipal Improvements, held at Milwaukee about three weeks ago, the committee on municipal data and the committee of which I first spoke, to secure action by the Census Bureau, were consolidated, and the new committee is empowered to act with other societies to this same general end.

It is the feeling of the chairman of the committee on municipal data of the American Society of Municipal Improvements that the schedule adopted and in use by the New England Water Works Association is not sufficiently extensive to meet the wants of the present day. That is a question which is certainly open to discussion; or, at least, it is questionable whether any more elaborate schedule than yours would be used to any great extent. The small number of works that have put it in use is good evidence on that point.

It seems to be desirable, in my opinion, to have a committee ap-

pointed by this Association to coöperate with similar committees from other societies. The Central States Water Works Association appointed such a committee to coöperate with a committee from your Association, or from any other, upon this matter of uniform water-works statistics, at its meeting the first of September.

There is, however, a broader field of work in this direction than along the line of water-works statistics alone. It is hoped by those who are interested in the movement in its broader aspects that all phases of municipal activity will be taken up, and that eventually there will be a joint conference committee which will cover the whole subject of municipal accounting and uniform municipal reports, the idea being that each society should do the detail work on its specialty, and then that all of the societies should adopt and try to further the introduction not only of uniformity in one line, but in the other lines. Some of the societies which are taking up this work are interested in all phases of municipal activity, like the National Municipal League, which is now holding its convention at Milwaukee, which will take up this matter on Friday afternoon, and very likely will appoint a strong committee on the subject. This body of which I have just spoken should not be confused with the American Society of Municipal Improvements, nor with the League of American Municipalities, which are two different organizations. The National Municipal League is the organization which has recently formulated and adopted a "Municipal Program," as it is called, which is in effect a skeleton or outline of a model municipal charter. It is a very strong and able organization, and it is hoped that it will take up this matter of municipal accounting from a broad standpoint, and present it and push it along all possible lines. It is a well-organized society with practically a permanent secretary, and is able to push the work onward.

As soon as the various societies have, each in its own field, formulated a scheme for their annual reports, it is to be hoped that they will go into the subject of uniform accounting, and that, later on, work will be begun in the various state legislatures to compel the municipalities of each state to make reports to a state officer in accordance with some uniform scheme. There is in Wyoming a State Examiner of Accounts, who has control of the accounts of the various municipalities, and who has full authority to require the municipalities to make their reports in accordance with his suggestions. Some of the other states in the Union have commissions

which deal with one subject only, like the Gas and Electric Light Commission in Massachusetts, and some of the states have commissions on street railways, and those commissions are requiring uniform reports. It now remains for the specialists, who are connected with such organizations as yours, to lay out schemes in these different fields; to show what is desired, because the municipal legislators, of course, are more or less ignorant on these subjects.

DISCUSSION.

MR. CHARLES W. SHERMAN.* As most of the members doubtless know, since the September issue of the JOURNAL is now in their hands, the statistics of water works, as far as they can be obtained from the reports of the works which have adopted our scheme, for the years 1897, 1898, and 1899, have been compiled, and are published in the September issue of the JOURNAL. This work was done by our senior editor, Mr. Beals, and I am very sorry indeed that he could not be here to present his views on this subject, as the result of his experience in compiling the three years' statistics for publication. I have had quite an extended conversation with him since his report was prepared for the press, and, as far as I can, I would like to give you the benefit of his experience as he has related it to me.

I am quite sure that he feels that our present schedule is, if anything, too elaborate. He says that no two superintendents follow the scheme as originally laid out in exactly the same way, and that, try as hard as he could, he found it absolutely impossible to tabulate some of the statistics presented, without the use of reference notes at the foot of the page, calling attention to some special manner in which a particular superintendent had departed from the scheme; and he questions very strongly whether it is not desirable to reduce the number of items tabulated, so as to make a simpler and less elaborate schedule rather than one so extensive as we have. It is possible, as I have recently heard suggested, that a more elaborate schedule might be adopted as the standard, which should be considered, perhaps, as an ideal which we would like to see followed if possible; and then another, which might be called a schedule of schedules, perhaps, and which should provide for a very condensed summary, even smaller than our present one, might be prepared for more general and uniform application.

* Junior Editor, N. E. W. W. Assn.

In any event, it seems to me that the subject is one which needs some attention from us. It is generally admitted that we are pio neers in this line and have done about the only good work which has been done, at least in the water-works line; and even that, we must admit, has been very small when, after a lapse of fourteen or fifteen years since the original report was presented, we find no more than twenty-eight cities and towns coöperating in furnishing this summary of statistics.

It is perhaps noticeable to a person who undertakes to compile these statistics that a number of men who seem to be enthusiastic in all the affairs of the Association, — in fact, one at least of our past presidents, — have not yet incorporated this scheme in their annual re-ports; and I think there is room for missionary work in calling the attention of superintendents to this subject, and in securing a more general adoption of this standard system of tabulating statistics. I think, also, that Mr. Beals' suggestions as to whether or not the schedules should be simplified should be taken up, and that the question of, perhaps, yielding some of our pet schemes, in order to secure greater uniformity throughout the country, if other societies are to adopt standard systems, so that one system may be standard throughout the United States, should be considered.

PROCEEDINGS OF THE NINETEENTH ANNUAL CONVENTION.

September 19 and 20, 1900.

RUTLAND, VT.,
September 19 and 20, 1900.

The headquarters of the Association during the convention were at "The Bardwell," and the meetings were held in the Rutland City Hall.

The following members and guests were in attendance: —

MEMBERS.

Charles H. Baldwin, Lewis M. Bancroft, Oren B. Bates, James F. Bigelow, Forrest E. Bisbee, George Bowers, Fred Brooks, Byron I. Cook, F. H. Crandall, George K. Crandall, George E. Crowell, August Fels, H. M. Gear, Julius C. Gilbert, Thomas C. Gleason, Albert S. Glover, W. J. Goldthwait, Frank E. Hall, J. D. Hardy, V. C. Hastings, W. C. Hawley, Rudolph Hering, Willard Kent, George A. Kimball, Leonard P. Kinnicutt, Morris Knowles, H. N. McIntosh, Theodore H. McKenzie, Thomas McKenzie, William Murdoch, Washington Paulison, Edward L. Peene, Henry W. Rogers, A. H. Salisbury, Charles W. Sherman, George A. Stacy, John C. Sullivan, Robert J. Thomas, William H. Thomas, D. N. Tower, E. L. Wallace, Charles S. Warde, John C. Whitney, W. P. Whittemore, and George E. Winslow. — 45.

HONORARY MEMBER.

F. W. Shepperd. — 1.

ASSOCIATES.

Garlock Packing Co., by J. W. Medick; Hersey Mfg. Co., by James A. Tilden and Albert S. Glover; Henry F. Jenks, Pawtucket, R. I.; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; H. Mueller Mfg. Co., by F. B. Mueller; National Meter Co., by John C. Kelley and J. G. Lufkin; Neptune Meter Co., by D. B. McCarthy; Rensselaer Mfg. Co., by Fred S. Bates; Builders' Iron Foundry, by F. N. Connet; Ross Valve Co., by William Ross; A. P. Smith Mfg. Co., by W. H. Van Winkle; Sumner & Goodwin, by Frank E. Hall; Thomson Meter Co., by Henry C. Folger and S. D. Higley;

Union Water Meter Co., by A. S. Otis; U. S. Cast Iron Pipe & Foundry Co., by John M. Holmes; Sweet & Doyle, by Edmund C. Doyle. — Associates represented, 16, by 19 representatives.

Guests.

Mrs. D. N. Tower, Miss Mary P. Tower, Cohasset, Mass.; Mrs. William H. Thomas, Miss Helen A. Thomas, Hingham, Mass.; Mrs. E. L. Wallace, Franklin, N. H.; Mr. and Mrs. Michael Walsh, Yonkers, N. Y.; Mrs. William H. Van Winkle, Newark, N. J.; Mrs. Byron I. Cook, Woonsocket, R. I.; Miss Mabel A. Bancroft, Miss Jennie M. Wilson, Reading, Mass.; Mrs. A. H. Salisbury, Lawrence, Mass.; Mrs. Edward L. Peene, Yonkers, N. Y.; Mrs. George K. Crandall, New London, Conn.; Hon. John O. Hall, Mrs. John O. Hall, Mr. and Mrs. C. F. Knowlton, Quincy, Mass.; Mrs. Willard Kent, Narragansett Pier, R. I.; Mr. and Mrs. James P. Bacon, Cambridge, Mass.; Mrs. Rudolph Hering, New York City; Miss Mary K. Gleason, Ware, Mass.; Mrs. George A. Kimball, Somerville, Mass.; Miss Helen M. Wales, Allston, Mass.; Miss J. M. Ham, Boston, Mass.; M. N. Baker, Associate Editor *Engineering News*, New York City; George E. Mather, Clinton, Mass.; Frederick Law Olmsted, Jr., Brookline, Mass.; L. M. Hudson, C. F. Holyoke, Thomas Burke, Marlboro, Mass.; A. M. Miller, Lt. Col. Corps of Engineers, U. S. A., Washington, D. C.; F. P. Laimon, C.E., Cambridge, N. Y.; Henry C. Meyer, Jr., *Engineering Record*, New York City; A. C. Grover, C.E., C. H. Murdock, A. L. Pratt, A. H. Pierce, L. H. McIntire, Water Committee, R. C. Royce, Hon. John D. Spellman, Mayor, Dr. J. A. Mead, President Howe Scale Co., J. F. Manning, President Columbian Marble Co., S. A. Howard, Superintendent, and Hon. Fletcher D. Proctor, President Vermont Marble Co., Rutland, Vt. — 46.

Summary of Attendance.

Honorary member	1
Members	45
Representatives of Associates	19
Guests	46
	111
Names counted twice	2
Total attendance	109

Wednesday, September 19.

The Association met at 11.30 A.M., President Cook in the chair.

The President. *Ladies and Gentlemen:* It gives me great pleasure to introduce to you His Honor John D. Spellman, Mayor of Rutland.

Address of Welcome by Mayor Spellman.

Mr. President, Ladies and Gentlemen: In behalf of the people of this city it affords me very great pleasure, as their executive officer, to extend to you, members of the New England Water Works Association and your lady friends and other visitors, the freedom and hospitality of our city during your stay among us. In doing so, permit me to say briefly that I have a keen sense of appreciation of this Association and of its purposes, and of the very many material advantages which the intelligence, the proficiency, and the skill of your membership have given to the business and the industrial life of New England cities, towns, and villages. I also have a keen appreciation of the fact that your members doubtless have a pretty fair knowledge, not only of the topography, but of the geography of New England, which in itself must of necessity have had a strong influence in inducing you to hold your annual meeting this year in the "Marble City."

Rutland we are proud of. As you will have an opportunity to observe before you leave us, and as you doubtless have observed already to a certain extent, our little city is pleasantly located, as we believe, in one of the richest and most fertile valleys of the Green Mountain State. It is surrounded by a beautiful amphitheatre of mountains and hills, which make it, at least in my judgment, one of the most charming spots, on account of its natural beauty, in all New England, if not in our entire country. We shall be pleased, very pleased, during your stay amongst us to show you, so far as we may be able in the limited time you are able to give us, the productions of this community. Among our chief industries, as you know, are the great marble quarries and shops, which have been the means of giving to this place, not only something of a national but also something of an international reputation. I again cordially invite you to the freedom and hospitality of our city. [Applause.]

The President. I assure you, Mr. Mayor, that we appreciate the words of welcome you have given us. The hospitality of your state and city is well known, and I have no doubt that our stay here will be profitable and pleasant. In behalf of the Association I invite you and the members of the city government and the citizens generally to be present at our meetings.

NEW MEMBERS ELECTED.

The Secretary read the following names of applicants for membership: —

For Resident Member.

Nelson E. Mather, Superintendent Water Works, Clinton, Mass.

W. W. De Berard, Assistant Biologist, Metropolitan Water Board, Boston.

Charles F. Knowlton, Commissioner of Public Works, Quincy.

George D. Curtis, Assistant Engineer, City Engineer's Office, Boston.

Charles-Edward Amory Winslow, Assistant in Biological Department, Massachusetts Institute of Technology.

Harry W. Stevenson, Chief Engineer Water Works Plant, Lowell, Mass.

Winfred D. Hubbard, Superintendent Sewers and Water Works, Concord, Mass.

For Non-Resident Member.

Daniel W. Mead, Civil Engineer, Chicago, Ill.

George A. Hotchkin, Superintendent Water Works, Rochester, N. Y.

On motion of Mr. W. H. Thomas, the Secretary was instructed to cast the ballot of the Association in favor of the applicants, and they were declared elected members of the Association.

The President then delivered his annual address, as follows.

ADDRESS OF PRESIDENT BYRON I. COOK AT THE NINETEENTH ANNUAL CONVENTION, RUTLAND, VT., SEPT. 19, 1900.

We are assembled to hold the nineteenth annual convention of this Association, and for a second time in the state of Vermont. Our journey thus far has been very pleasant, and I hope the further proceedings will be as enjoyable. We have again tested the hospitality of the people of the Green Mountain State, and it is found correct.

I will not take time this morning from the more important program that is to follow for any extended remarks, but will simply review the work of the year just closed.

Our net gain in membership for the year has been 24; average for the past five years, 25. The average attendance at our winter meetings was 90.

Our resident active membership is small. Of the three hundred and seventy-three water works in New England, costing over $100 000, only seventy-eight, or less than twenty-five per cent., are represented in our Association. Every water-works superintendent in New England should be a member. It is a duty that he owes to himself and to the plant he operates. We all know that a superintendent with a small salary cannot afford to attend all our meetings, and this is without a doubt the reason why more of the superintendents in the smaller towns are not members. But if a superintendent cannot afford to become a member, the city, town, or company by which he is employed should assume the expense; it will be money well invested. One of the most important questions in water-works management to-day is how to check the waste, and I can safely say that the knowledge which can be gained from the papers read at our meetings, from the association with other members, and from our JOURNAL, will be more effective in checking the waste in any water-works plant than the best meter manufactured, even if it does register one one-hundredth of an inch flow.

The influence and the success of our Association will depend largely on the publication that we issue, and I fully concur with the opinion expressed by Past-President Forbes in his address last year, that our JOURNAL should be the leading water-works publication in this country. The Editors alone cannot make it so, — they need your individual assistance. To their circular issued during the year in regard to advertisers I call your attention, and hope you will aid the JOURNAL in every way possible. There has been an increased demand for the JOURNAL during the year, and this is largely due to the efforts of our Junior Editor, Mr. Sherman, who has so ably performed his duties. Our JOURNAL should be on file in every water department in this country as a reference book for both construction and maintenance.

I hope the day is not far distant when there will be adopted a universal form for the annual reports of municipal water departments, — an object for which this Association has long striven.

The June issue of our JOURNAL, containing a description of the largest sand filter plant in this country, together with a description of the mechanical or American method of filtration, with the discussions by prominent professional gentlemen, is a very valuable book on the purification of water.

The paper on electrolysis, condemning the present method of transmitting electrical power for the operation of street railways, and recommending the double trolley system as the only sure way to prevent the electrical current from escaping into the ground and causing serious injury to the various piping systems, relates to what is probably one of the most important questions that will have to be solved by water-works officials in the next few years.

Mr. Crosby's paper on "Eliminating the Conflagration Hazard," read at our March meeting and not yet published,* the paper being confined to protection from fire by the sprinkler system, presented arguments that must be squarely met by the water-works people, for more than $150 000 000 of property was destroyed by fire in this country last year, and at the present rate the loss this year will be greater. If by united action of the insurance and water-works officials that loss can be reduced, it is our duty to make that effort. The sprinkler system for fire protection is rapidly being extended, requiring larger street mains. A 4-inch sprinkler connection is a thing of the past, and the laying of nothing larger than a 6-inch main to protect a manufacturing industry from fire is sure to result in large loss if a fire occurs.

I hope the Association will take some action on the suggestion contained in Mr. Coffin's paper entitled "A Few Notes on Cast-Iron Pipe," and adopt a standard specification for cast-iron pipe, to be called the New England Water Works Association Standard Cast-Iron Pipe Specification, and that special investigation be made on the coatings of pipes. From personal observation I find that the cast-iron pipe of to-day is not as well coated as in former years.

The committee appointed to revise our constitution are ready to report. Their report, approved by your Executive Committee, has been mailed to each member, and comes up for your action later in the session. I hope that it will be thoroughly discussed and that every member will express his opinion on its provisions.

The Association has lost by death during the year the following members: —

* Printed in this issue. — EDS.

N. W. Conant, Superintendent of Water Works, Gardner, Mass., died November 18, 1899.

Nathaniel Dennett, Superintendent of Construction, Somerville, Mass., died February 21, 1900.

Horace B. Winship, C.E., Norwich, Conn., died November 8, 1899.

Nathan B. Bickford, 61 Minot Street, Neponset, Mass., died June 24, 1899.

Andrew Holden, Water Commissioner, Fall River, Mass.

James W. Morse, Superintendent of Water Works, Natick, Mass., died September 23, 1899.

John C. Haskell, Superintendent of Water Works, Lynn, Mass., died June 12, 1900.

Of those who have passed away, Mr. Haskell was probably best known to the members, he having been prominent in the affairs of this Association, serving as its President in 1896 and 1897. He was an active member in every sense, and his work in the Association will be greatly missed.

To the officers and members I wish to express my thanks for their assistance in the management of the affairs of the Association during the year; and I hope you have not had cause to regret the selection that you made for your presiding officer last year at Syracuse.

TREASURER'S REPORT.

Mr. Lewis M. Bancroft, the Treasurer, then presented his annual report, as follows: —

Lewis M. Bancroft, Treasurer,

In account with the New England Water Works Association.

RECEIPTS.

1899.			
September 5.	Balance on hand as per last report		$2 712.40
November 16.	Received from Willard Kent, Sec'y . . .	$91.95	
1900.			
January 1.	Received from Willard Kent, Sec'y . . .	78.00	
13.	" " " " " " . . .	193.00	
23.	" " " " " " . . .	193.80	

January 30.	Received from Willard Kent, Sec'y	$165.00	
February 6.	" " " " "	192.00	
13.	" " " " "	113.40	
March 6.	" " " " "	119.00	
13.	" " " " "	48.00	
April 3.	" " " " "	151.50	
May 1.	" " " " "	143.65	
7.	" " " " "	146.20	
21.	" " " " "	121.20	1 756.70
			$4 469.10

EXPENDITURES.

1899.		
October 20.	J. C. Whitney, salary and expenses	$243.12
	W. H. Richards, salary and expenses	95.00
	Bacon & Burpee, report of September meeting	80.00
	Day Publishing Co., September JOURNAL	318.99
December 12.	D. Gillies' Sons, printing and stationery	144.43
15.	J. M. Ham, salary and express	78.69
	Library Bureau, pamphlet boxes	4.80
	W. T. Almy, badges	31.60
19.	Charles W. Sherman, salary and expenses to December 1	97.66
	Boston Society of Civil Engineers, rent to December 1	200.00
1900.		
January 1.	Willard Kent, salary to December 1, postage, etc.,	70.00
	American Society Civil Engineers, book-binding	6.00
	D. Gillies' Sons, printing	13.92
	J. S. Roberts, express	1.55
15.	Newton Journal, printing	66.00
	W. N. Hughes, receipt book and bill heads	11.45
	Boston Mailing Co., mailing JOURNAL	4.33
	Samuel Hobbs & Co., stationery	3.62
19.	Francis L. Pratt, music at December and January meetings	40.00
	Thomas P. Taylor, stereopticon, December and January meetings	20.00
	Association of Engineering Societies, cuts	5.56
24.	Suffolk Engraving Co., cuts	85.70
31.	Samuel Usher, printing December JOURNAL	291.65
February 1.	J. M. Ham, salary to January 15, and postage and express	50.42
22.	Francis L. Pratt, music at February meeting	20.00
26.	Association of Engineering Societies, printing plates	25.00

March 2.	Samuel Usher, printing	$2.25
	Thomas P. Taylor, stereopticon, February meeting	10.00
	W. N. Hughes, perforating lists of subscribers	2.50
	J. M. Ham, salary to February 15, express, etc.	27.33
9.	Irons & Russell, buttons	178.50
	Willard Kent, salary to March 1, and expenses	80.05
	Charles W. Sherman, salary to March 1, and expenses	94.00
	Boston Society of Civil Engineers, rent to May 1	100.00
16.	Library Bureau, case and cards	20.85
21.	D. Gillies' Sons, printing	62.75
	Francis L. Pratt, music at March meeting	20.00
	Evening Post, electrotypes	17.10
April 5.	John Venner, calcium lights, September, 1899, convention	11.00
	John Wiley & Sons, electrotype	1.55
10.	D. Gillies' Sons, pamphlet envelopes	30.65
	J. M. Ham, salary to March 15, express and postage	30.05
	A. S. Glover, telephones, September, 1899, convention	7.00
	W. N. Hughes, membership book, etc.	19.75
	Boston Mailing Co., mailing pamphlets	1.50
23.	Bacon & Burpee, reporting winter meetings	66.25
	Hub Engraving Co., plates	46.12
May 2.	Boston Elevated R. R. Co.	10.80
	W. N. Hughes, numbering book	1.75
8.	Samuel Usher, printing March JOURNAL	252.85
	D. Gillies' Sons, letter heads and envelopes	37.25
	J. M. Ham, salary and expenses to May 15	57.36
		$3 198.70

BALANCE ON HAND.

Deposit, People's Savings Bank	$1 184.03	
Deposit, First National Bank, Reading	86.37	1 270.40
		$4 469.10

LEWIS M. BANCROFT, *Treasurer.*

BOSTON, MASS., September 13, 1900.

Accounts of Treasurer, as per preceding pages, examined and found correct.

A. W. F. BROWN, *Committee on Finance.*

On motion of Mr. August Fels, the report of the Treasurer was accepted and placed on file.

REPORT OF THE SECRETARY.

Mr. Willard Kent, the Secretary, submitted the following report, which was received and placed on file: —

SUMMARY OF STATISTICS RELATING TO MEMBERSHIP FOR YEAR ENDING JUNE 1, 1900.

ACTIVE MEMBERS.

June 1, 1899.	Total active membership		494	
	Withdrawals during year:			
	Resignations	6		
	Dropped	2		
	Died	6	14	
			480	
	Initiations during year:			
	September	9		
	December	14		
	January	4		
	February	7		
	March	5	39	519

HONORARY MEMBERS.

June 1, 1899.	Honorary members	5	
„ 1, 1900.	„ „		5

ASSOCIATE MEMBERS.

June 1, 1899.	Total associate membership		73	
	Withdrawals during year		5	
			68	
	Initiations during year:			
	December	1		
	March	1	2	70
June 1, 1900.	Total membership			594

Since June 1 one of our members has died and four have resigned, but the election of five new members makes our total membership at date of this meeting unchanged from that of June 1, 1900.

WILLARD KENT, *Secretary.*

REPORT OF THE JUNIOR EDITOR.

Mr. Charles W. Sherman, Junior Editor, presented the following report, which was received and placed on file: —

BOSTON, July 1, 1900.

To the President and Members of the New England Water Works Association:

It has not been customary hitherto to have a report for the JOURNAL; but bearing in mind the fact that the expenditures on account of the JOURNAL comprise a large part of the cost of running the Association, and that a considerable number of our members who are unable to attend the meetings know nothing more about the affairs of the Association than what they read in its pages, it has seemed to the present Junior Editor that such a report would be of interest to the membership. He therefore submits the following as the FIRST ANNUAL REPORT OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

Volume XIV of the JOURNAL, which was closed with the issue for June, 1900, contained 375 pages of text and 8 pages of volume index, etc., a total of 383 pages. Including advertisements and covers, the total number of pages printed was 485. It was illustrated by 42 cuts and 26 folded or half-tone plates, the latter of which are not included in the count of pages, although they might well be.

The detailed statement of the contents of the JOURNAL is given in the following table: —

TABLE NO. 1.

Statement of Material in Vol. XIV, Journal of the New England Water Works Association, 1899–1900.

Number.	Issue.	Number of Pages of						Cuts.	Half-tone and Folded Plates.
		Papers.	Proceedings.	Volume Index.	Total Text.	Advertisements.	Total Pages.		
1	September ..	87	9	—	96	22	118	2	4
2	December...	77	21	—	98	20	118	10	1
3	March	91	5	—	96	20	116	9	13
4	June.....	82	3	8	93	20	113	21	8
					383	82	465	42	26
	Covers and Contents						20		
							485		

The total cost of issuing the JOURNAL was $1 954.15, made up as follows: —

TABLE NO. 2.

Cost of Vol. XIV, Journal of the New England Water Works Association, 1899–1900.

Printing	$1 085.71
Engraving, etc.	184.43
Postage on JOURNAL	27.34
Junior Editor's salary	300.00
Stationery and postage	62.61
Incidental expenses	35.38
Reporting meetings	146.25
Printing reprints of papers	112.43
	$1 954.15

The total cost of illustrating was $219.93, or eleven per cent. of the total cost of the JOURNAL. I believe this percentage could be increased with advantage to the JOURNAL. The cost of the illustrations in the *Journal of the Association of Engineering Societies* for 1899 was about seventeen per cent. of the total cost of issuing that journal. Lack of funds has operated to restrain us from illustrating papers so fully as we should have liked to do.

The total receipts which should be credited to the JOURNAL have been $1 606.60, made up as follows: —

TABLE NO. 3.

Receipts credited to Vol. XIV, Journal of the New England Water Works Association, 1899–1900.

Advertising	$1 245.00
Sales of JOURNALS	201.65
Sales of reprints	48.65
Sales of cuts	19.30
Subscriptions	92.00
	$1 606.60

It should be noted that this does not include any part of the receipts from members.

The excess of expenditures over receipts is $347.55, which may be considered as the *net cost* of the JOURNAL.

It is worthy of notice that the amount of advertising is less than it was a number of years ago, when the circulation of the JOURNAL and consequently its value as an advertising medium were considerably less. This is due to two causes: first, the withdrawal of their advertisements by some firms which we think ought to advertise with

us; and second, to the formation of "trusts," giving us one advertisement, or none at all, where formerly we had several. The present circulation is: —

Members (all grades)	594
Subscribers	46
	640

In accordance with the custom of the Association, authors have been furnished with fifty reprints of their papers, free of charge. In cases where more than this number were wanted, they have been supplied at cost. The expense of furnishing these reprints to authors has averaged about $4.25 for each paper.

The following table shows that taking into account the difference in the number of copies printed and number of issues during the year, our JOURNAL compares very favorably with the *Journal of the Association of Engineering Societies.*

TABLE NO. 4.

Comparison between the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION *for 1899–1900 and the Journal of the Association of Engineering Societies for 1899.*

	Journal of the New England Water Works Association.	Journal of the Association of Engineering Societies.
Average edition (copies)	1 100	2 200
Issues during year	4	12
Average membership (all grades)	583	1 475
Number of pages of papers	345	544
Do. per 1 000 members	600	369
Total number of pages	485	957
Do. per 1 000 members	832	649
GROSS COST OF JOURNAL:		
Total	$1 954.15	$3 233.44
Per page	4.03	3.38
Per member	3.35	2.19
Per member per 1 000 pages (all kinds)	6.91	2.29
Per member per 1 000 pages (papers)	9.71	4.03
NET COST OF JOURNAL:		
Total	$347.55	
Per page	0.717	
Per member	0.596	
Per member per 1 000 pages (all kinds)	1.23	
Per member per 1 000 pages (papers)	1.73	

Respectfully submitted,

CHARLES W. SHERMAN,
Junior Editor

THE REVISION OF THE CONSTITUTION.

Mr. George A. Stacy, chairman of the committee appointed to prepare a draft for a revised constitution, then addressed the convention. He said: —

The committee appointed to revise the constitution of the New England Water Works Association, when they took the subject in charge, realized that they had no small task on hand, as the constitution was, with very few changes, the one which had been adopted at the organization of the Association years ago, when its numbers were very small. Our present membership is over half a thousand, and it shows the wisdom of those few, who were really the fathers of this organization, that the constitution which was adopted at that time has done its duty so well, and has answered our purpose for so many years. Yet it was felt that the Association had grown to be so large that we ought to consider whether the old constitution did not need some revising or changing. Upon looking the matter over we have come to the conclusion that most of it will do for us to-day; we cannot see that anything we could devise would, in many particulars, serve us any better.

There are certain articles in the old constitution, however, that in our judgment require radical changes. We have had numerous meetings, and have studied and digested the subject to the best of our ability, and have presented the result of our deliberations in printed form, which has been sent to every member of the Association. While we were delegated with full power to report, without consultation with any other members of the Association, we thought best to present our conclusions to the Executive Committee, which has done so much for the success of this Association in times past; whose wisdom, indeed, has very largely carried this Association to its present position of influence and membership. Whatever recommendations they may make in the way of amendments to the printed form of the constitution as we have presented it to you, we will cheerfully accept.

To my knowledge there is only one change that they recommend, and that is in section five of article two, which as reported by us reads: "Members engaging in the business of furnishing water-works supplies shall cease to be Members of the Association and their names shall be transferred to the list of Associates." The

Executive Committee suggests that that be amended so as to read: "Members *hereafter elected* engaging in the business of furnishing water-works supplies shall cease to be Members of the Association," etc. If a motion is made to amend in that way, the members of the revision committee are willing to accept that amendment. And as this report has been in the hands of the members of the Association, as I understand, for quite a while, you are certainly competent to judge whether this is what you want, or whether you want to change it. We have done the best we could. We know our work is not perfect — if we worked over it all our lives it probably would n't be — but this is the best we could do with our experience and our study; and we now present it to you in this printed form for your adoption, amendment, or rejection, as it meets your pleasure.

Mr. Robert J. Thomas. I move that the report of the committee be accepted, and that the new constitution as proposed in their report, with the amendment providing that members "hereafter elected" are the ones referred to in section five of article two, in other words, amending that section so that it shall read: "members hereafter elected," instead of "members" as it reads now, be adopted.

Mr. T. H. McKenzie. I think I do not fully understand Mr. Stacy with regard to the matter of members who are hereafter elected being dropped as Members when they engage in the sale of water-work appliances. I suppose he intends it to apply also to those who are now active members of the Association, if they engage in the sale of water-works appliances. They would under that be transferred, would n't they?

Mr. Stacy. Perhaps I did not make myself clear in this matter, and the phraseology of that section, perhaps, is not just as it should be; but the intention is to leave the members of the Association at the present time in the same standing that they are to-day, and anybody elected to this Association hereafter, or any Member hereafter who ceases to be an active water-works man, in all its true sense, and goes into the business of furnishing water-works supplies, or the business of furnishing us with goods required for the construction and maintenance of water works, shall not be considered an active member, but shall cease at that time to be a Member and shall be put on the list of Associates. It has no effect on the Members' standing in the past, or the Members' standing at the time that this is adopted. I don't know whether I make myself clear or not.

Mr. Julius C. Gilbert. I would like to say a word. I do not

know as it is becoming in me, being a very modest member of this Association, to disagree with or oppose anything which may come up here; but, really, I cannot say that I agree with all these amendments which are offered. I don't know but this is all right; I think that the committee has been honest and has offered it as the best thing to be done; but still, of course, if some of us differ in our opinions, we beg leave to let it be known in the meeting. Here are only a few of us in attendance to-day, compared with the whole active membership, and of course the vote will be small, only a very small number of the members being present to vote on these amendments.

There are a few questions which I would like to ask, and first, in regard to the dues. I for one would be perfectly willing to pay any reasonable amount as dues, if it were necessary, but I would like to ask why the dues are to be raised? If the Association is out of funds and needs more money, then I say raise the dues; but, if we have money enough to get along as we have been getting along, why should we raise them?

But I will go on and not wait for an answer to that question at the present time. Again, in regard to the election of officers; it seems to me that a constitution which has served this Association for so many years, although its membership has increased from a small to a very large number, is all right for the large number. There is no other way in the world of choosing a set of officers so fair, honest, and democratic as by choosing them in open meeting. I understand from the committee that they make this change so that every member of the Association shall have a chance to vote. We all wish that every member could be present and vote at the annual meeting for the election of officers, but that is impossible. Now, it seems to me that those very people to whom you wish to give a chance to vote, who live at a great distance from the headquarters, will, under this amendment, really have no choice in the election of officers, unless they are perfectly satisfied with the list sent out by the nominating committee. If a man lives two or three hundred miles from the place of holding the meeting, he has no other knowledge than that certain men have been nominated for officers, and if they are satisfactory to him he returns his vote by letter. But supposing they are not satisfactory to him? He can, perhaps, send a vote for some one else by letter, but supposing two or three hundred members wanted to vote for some one else other than the nominees, you might have

two or three hundred candidates. That is the main objection that I have to these amendments.

I don't want any member of the committee, or any member of this Association, to think I am saying this to find fault, or that I am dissatisfied in any way whatever personally. I say this only for the best interests of the Association; and from what I have heard since leaving home, it seems to me that the active members of the Association would be better satisfied to have things stay as they are in this respect than to have them as they would be if these amendments are adopted. I want to say this, in closing, that if a majority wants the amendments, I shall go away just as well satisfied as I otherwise would be, for I have no personal feeling in regard to it in any way.

Mr. Stacy. Mr. President, as chairman of the committee I will try to answer the objections of the member who has just made this very frank statement. One objection, I understand, is to the raising of the dues, — that is, if we have got money enough to run the organization without raising them. Now this committee, if it had been satisfied that we were raising money enough with the present dues to run the organization, would have been decidedly wrong in proposing any larger assessment. But the fact is that the finances are going behind, and that is the reason that we recommend raising the dues. We have n't waited until we were in a hole. We have got a good financial foundation now, which is the bed-rock upon which any association must rest, and the committee wants to keep it sound. Now it seems to me that three dollars a year is a pretty small sum for the benefits derived from the meetings of the Association and from our Journal; and that sum is needed from each member, according to the views of your committee, in order to keep the Association up to its present financial standard.

Now, as far as the election of officers is concerned, that is perhaps rather a tender subject. We have been drifting along in the old ruts for a long while, until it has been whispered around amongst a few that there is a possibility of a ring running the Association. It is true that we have been very fortunate in the selection of our Presidents and other officers — with the exception of one President a few years ago — even under the present system of nominating them by a committee. You did n't know whom they were going to nominate, — and they themselves did n't sometimes a half an hour before they made their report. You are fortunate in having such a membership

that the committee could n't make any serious mistake, even if they had taken the names of their nominees consecutively from the membership list. But perhaps the New England Water Works Association won't always keep its membership up to such a high standard that a committee could safely do that; and, at any rate, it seems a rather crude way to do as we have been doing. I know of two or three cases, to speak plainly, where the committee on nominations had no meeting at all, was n't even present at the convention to report, and half an hour before the time for the report a new committee had to be appointed. I know that to be a fact. Now, no committee can do justice to the Association by going in and nominating a set of officers fifteen or twenty minutes before the time the names are brought before the convention, without giving the matter any more consideration than that.

Now, in studying the question how to remedy that defect, as it appeared to us, we looked to other organizations to a certain extent, as we have in our everyday life to look to the experience of others and adapt that to our own situations; and we considered that the method we have proposed was the fairest and most equitable way in which our officers could be selected. You will notice every member is to be notified, and any ten members — you can't have three or four hundred different sets of nominations for officers — ten members, I think it is, can make nominations for the various offices and present them within a limited time to the Secretary, and they shall be published in the list and be voted upon.

Now, it seems to me, that gives every man a chance to know who the nominees to be voted for are, it gives any ten members who are interested in the Association a chance to get together and make independent nominations, it prevents confusion, and it gives every one a chance to vote intelligently on the officers whom he wishes to have serve the Association for the coming year. If there can be any improvement suggested on that, your committee will be glad to adopt it, and I am sure the Association will. There are but few of us here to-day, but every member of the Association knows what this proposed amendment is, if he has taken the pains to read the papers which have been sent to him; so it seems to me it comes before you at this time fairly and squarely, and that every man should know how he wants to vote upon it. The purpose of the committee has been to recommend a plan by which every member of the Association might have something to say upon the vital question of who the officers of

the Association shall be. I don't suppose it is perfect, but it seems to me it is a very long step in advance of the old constitution in the method of electing officers, now that the membership has grown so large.

Mr. C. W. Sherman. Just a word, to supplement Mr. Stacy's explanation. It seems to me that the report of the Treasurer, submitted a few minutes ago, is all the argument that is needed for the increase in dues. If I remember the figures correctly, the amount of money in the treasury a year ago was $2,700, or thereabouts; the amount on hand to-day is between $1,200 and $1,300. I think those figures speak for themselves.

Mr. Robert J. Thomas. I would like to say, as a member of the Executive Committee, that we went over these proposed amendments very carefully and discussed them *pro* and *con;* and although some of the members at first were opposed to certain sections in the different articles, after considerable time spent in the consideration of them the committee voted unanimously to recommend them; and that is one reason why I made the motion here to adopt them.

Mr. Morris Knowles. Referring to section five of article two, the proposed amendment, suggested by the Executive Committee, is, as I understand it, to insert after the word "Members" in the first line the words "hereafter elected." I rise principally for the purpose of seeking information upon that, as to whether my interpretation of it is correct. As I should interpret that it would mean that any one hereafter elected to the Association as a member who goes into the business of supplying water-works materials would drop his active membership and become an Associate; but that any one who is now an active member of the Association who enters the business of furnishing water-works supplies would not be affected by this amendment. If that interpretation of it is correct, it seems to me decidedly unfair, — that is, if any one who hereafter connects himself with the Association will be affected by it, and any one who is now a member will not be. If it is desired not to affect any one who has been an active member, and who is now doing work similar to that of an Associate, it seems to me the simplest way to accomplish that is to let the constitution stand as proposed by the committee; for, unless we pass a vote to that effect, the new constitution will not be retroactive and will not affect the old members.

Mr. R. J. Thomas. I don't think Mr. Stacy has got the idea of this proposed amendment exactly as the Executive Committee in-

tended it. Their intention was that the amendment should apply simply to members hereafter elected, and if any present Member of the Association goes into the supply business he is not to be affected by it, nor is any Member who is now engaged in the supply business; but any person hereafter coming into the Association should understand, before becoming a member, that if he goes into the supply business afterwards he is to be transferred to the list of Associates. But we think the present members should have the same right to go into the supply business as those who went into it some years ago, or went into it last year, even though the members hereafter elected should not have that privilege. And I don't see that there is anything unfair in that to the members to be hereafter elected, because they will understand it perfectly before they are elected. The unfairness, I think, would come if we made any discrimination between the members who are now in the supply business and those members who may go into it next year.

MR. STACY. I am glad that this point has been brought up, for I believe in having a clear understanding now, so that there will be no confusion hereafter. As I understand it now, the amendment recommended by the Executive Committee is intended to provide that this section shall have no effect in any shape or manner upon the present membership, but will only have an effect on persons elected to membership in the future.

* * * * * * * *

THE PRESIDENT. I will state that the amendment proposed is as follows: —

"Members *hereafter elected* engaging in the business of furnishing water-works supplies shall cease to be Members of the Association and their names shall be transferred to the list of Associates."

MR. KNOWLES. I would like to offer an amendment to the amendment proposed by the Executive Committee, that is, to strike out the word "elected" after "hereafter"; so it will read: "Members hereafter engaging in the business," etc. And also, to insert after the word "transferred" the words "by the Secretary." The reason for the first amendment is evident, I suppose, from the remarks which have been previously made. The reason for the second is that it will place a definite duty upon a definite person, and will not leave it in an indefinite state.

MR. SHERMAN. With reference to the second of Mr. Knowles'

suggestions, that the duty of transferring such a name from the list of Members to the list of Associates be delegated definitely to the Secretary, I will say that a later section of the revised constitution as proposed here delegates the business of the Association, not otherwise specifically assigned to some officer, to the Executive Committee; and it seems to me preferable that the duty of transferring such a name to the list of Associates should be left to the Executive Committee rather than to a single officer such as the Secretary, because it is sometimes rather a delicate question to decide whether a man has gone into the water-works supply business, or whether he is still a water-works man. For that reason I think the committee is better than the Secretary.

Mr. R. J. Thomas. I don't see why we should discriminate against the members who are not in the supply business now in favor of those who are in the supply business. We can't get at the members who are in the supply business, because we can't pass an article which is retroactive, and I don't believe that is sufficient reason why others, who have been lifelong active, interested members of this Association, should be dealt with differently. There would be nothing unfair to persons coming in hereafter, because we would be taking nothing away from them. They will understand before they come in just what their rights are. But by this proposed amendment to the amendment you are taking something away from the old members, and I don't believe in it. I think the constitution as reported by the committee and approved by the Executive Committee is all right.

Mr. Stacy. I think the point that we should delegate the Secretary to do this work, rather than the Executive Committee, is a small one. The constitution will require them to do it with their other work.

Mr. Knowles. I agree it is a small point, and I have no objection to accepting Mr. Sherman's suggestion as to the Executive Committee.

The President. The motion before the house is on the amendment to the amendment offered by the Executive Committee to section five of article two: "Members hereafter engaging in the business of furnishing water-works supplies shall cease to be Members of the Association, and their names shall be transferred to the list of Associates."

The amendment to the amendment was defeated.

THE PRESIDENT. The motion is now on the adoption of the revised constitution with the section as amended by the committee: "Members hereafter elected engaging in the business of furnishing water-works supplies shall cease to be members of the Association, and their names shall be transferred to the list of Associates."

Adopted, 14 to 5.

MR. W. H. THOMAS. Do I understand this adopts the revised constitution entirely?

THE PRESIDENT. That was Mr. Thomas' motion. The report of your committee is adopted.

MR. J. C. GILBERT. As the constitution as amended has been adopted, I suppose it really takes the authority away from the old Nominating Committee. I would, therefore, move that the present Nominating Committee be reappointed by the President as the committee on nominations.

The motion was adopted, and the President reappointed as the Nominating Committee: J. C. Whitney, Newton, Mass.; C. K. Walker, Manchester, N. H.; F. F. Forbes, Brookline, Mass.; P. Kieran, Fall River, Mass.; D. N. Tower, Cohasset, Mass.

The Secretary read a communication from the Indianapolis Board of Trade, inviting the Association to hold its next convention in that city.

MR. SHERMAN. This new constitution has been so thoroughly read by the members, as has been evinced by the interest taken in it, it is perhaps unnecessary for me to call attention to article eight, section one, which reads: "A convention of the Association for the reading and discussion of papers and for social intercourse shall be held annually at such time and place as may be determined by the Executive Committee." Of course that does not mean that the Executive Committee is not glad to know and would not be governed by the wishes of the members, but the power to determine upon the place for the annual convention is in the hands of the Executive Committee.

MR. STACY. I move that the invitation be referred to the Executive Committee, and that they report upon it at a subsequent meeting.

Adopted.

MR. W. C. HAWLEY. I did n't expect to bring the matter up at this time, but it seems to be in order now, and therefore I will mention it. We would be very glad indeed to have the next convention

of this Association held at Atlantic City. We are unable to offer you very much in the way of entertainment, because Atlantic City has so many conventions, and so many that are large, that bring thousands of people there, that it would be very difficult to secure entertainment for a convention of two or three hundred people. However, we feel sure that the members of the Association would enjoy themselves there, and that we could provide every facility for having a pleasant and profitable time. We would be very glad indeed to see you, and we will do what we can to entertain you.

THE PRESIDENT. In behalf of the Association I thank you, Mr. Hawley, for your kind invitation. If there is no objection, Mr. Hawley's invitation will take the same course as that from Indianapolis.

AFTERNOON SESSION.

Mr. Henry F. Jenks made the following report of the Committee on Exhibits of Associate Members.

The following have made exhibits at this convention: —

Meters. — The Hersey Manufacturing Co., South Boston, Mass.; Henry R. Worthington, New York City; Thomson Meter Co., Brooklyn, N. Y.; Union Water Meter Co., Worcester, Mass.; National Meter Co., New York.

Water-Works Tools and Supplies. — Sumner & Goodwin Co., Boston, Mass.; The A. P. Smith Mfg. Co., Newark, N. J.; The H. Mueller Manufacturing Co., Decatur, Ill.

Valves. — Sweet & Doyle, Cohoes, N. Y.; Ross Valve Co., Troy, N. Y.

Miscellaneous. — Henry F. Jenks, Pawtucket, R. I., Drinking Fountains; Garlock Packing Co., Palmyra, N. Y.; Lead-Lined Iron Pipe Co., Wakefield, Mass.

MR. PEENE. Mr. President, as the new constitution allows your conventions to be held outside of New England, the city of Yonkers invites the Association to meet in that city in 1901 or 1902. It is a place central to all railroad lines; it is situated on the banks of the noble Hudson; it is within twenty minutes' ride of the site of the immense distributing reservoir which is now building by the city of New York, and on the north is the immense dam constructed in the valley of the Croton.

THE PRESIDENT. I thank you, Mr. Peene, in behalf of the Association, for your invitation. It is very flattering to us that so many cities want us to come to them. If there is no objection, the invita-

tion from Yonkers will take the same course as the other two did this morning.

Prof. Leonard P. Kinnicutt, of the Worcester Polytechnic Institute, Worcester, Mass., then read a paper on "The Purification of Sewage by Bacterial Methods," which was illustrated by charts, diagrams, and tables. It was discussed by Mr. Rudolph Hering, of New York, and the author.

EVENING SESSION.

Mr. Morris Knowles, Assistant Engineer in charge of the testing station, improvement and filtration of water supply, Philadelphia, Pa., described, with the aid of the stereopticon, the filtration experiments and plant at Pittsburgh, Pa.

At the conclusion of Mr. Knowles' address the President called upon Mr. M. N. Baker, Associate Editor of the *Engineering News*, to give a talk on the subject of uniform statistics in municipal reports, reminding the members at the same time that the New England Water Works Association may be said to be a pioneer in that line.*

Mr. Charles W. Sherman. Mr. President, I move you that a committee of three members be appointed to consider this question of uniform statistics, and to consider what, if any, coöperation with other societies is desirable; that the committee be authorized to hold conferences with similar committees from other societies, and to report at a later meeting, whenever the information in their hands is sufficient, as to what steps it seems desirable for this Association to take.

The motion was adopted and the President said that he would announce the committee later.

THURSDAY, SEPTEMBER 20.

The day was devoted to excursions to the marble quarries and other points of interest.

EVENING SESSION.

Mr. J. C. Whitney offered the following resolution: —

Voted, That the thanks of the New England Water Works Association be extended to His Honor the Mayor, to the City Government, and to the

* Mr. Baker's address is printed on page 189 of this issue.

citizens of Rutland; also to the officials of the marble companies and to the Howe Scale Co., for the many courtesies which have made our visit to the Marble City most enjoyable.

Adopted by a rising vote.

THE PRESIDENT. We have had with us as a guest during our trip and during our convention a gentleman who is greatly interested in municipal affairs, and it gives me much pleasure to present him to you now, — Mayor Hall, of Quincy, Mass. [Applause.]

Address of Mayor John O. Hall, of Quincy.

Mr. President: I did not anticipate anything of this sort until a little remark which you dropped in my hearing this evening. I expected as your guest merely to join you in the pleasures which you had mapped out for yourselves, to be simply a recipient of your kindness, rather than to take any part in your meetings. It would be the height of discourtesy in me, however, if I did not return to you, Mr. President and gentlemen, my thanks for the invitation to join you in these festivities, and I assure you that the thanks which I return to you are heartfelt and sincere.

Meetings of this sort are of inestimable value. Their influence and their power are beyond calculation. It is a serious mistake if those who are connected with the administration of municipal affairs do not at every opportunity come together for conference, for the interchange of opinions, for the accumulation of facts and experiences outside of their own particular circles, in order that the work which they are called upon to perform may approach to perfection in the highest possible degree. We all have our duties, we all have our burdens, we all have perplexing questions to deal with, which apply to our own individual surroundings, but they are lightened wonderfully by such intercourse as it has been our privilege to enjoy during the past week. We sit with our elbows on the table and our head in our hands, studying to overcome the difficulties that press upon us and which seem to be insurmountable; but after an experience of this sort they vanish into thin air, and an inspiration comes which settles them all, and the problems with which we have struggled and labored for days are solved by our contact with other minds that have also been wrestling with them. You know that if you take two iron pipes that are covered with rust, all corroded, and let them roll together for a little while, the surfaces are smoothed,

and they look more like serviceable pipe. You know that in the process of mechanics the highest degree of polish is secured when certain articles are placed in a tank and rolled and rolled back and forth, and you have all seen them come out shining, glistening, and brilliant. It is just the same with us in our social life, it is just the same with us in our business life, it is just the same with us as we mingle day by day with our fellow men in the accomplishment of those objects which seem to be desirable and essential. And as we mingle together, as we rub one against the other, as mind meets mind, as kindly greeting answers kindly greeting, we go forth brightened and better equipped for usefulness in the spheres which we occupy. That is the result of just such meetings as these; and I return to you my thanks again for just this inspiration and this increased power and this possibility of greater usefulness which I feel have come to me from meeting with you, and which always come from such meetings when we attend them in the right spirit.

Of course I am not a water engineer. Your department is unfamiliar to me in its detail, your minds travel in a channel of which I am almost entirely ignorant; but we are all bound together really in securing the accomplishment of one great end, and that is the improvement of our municipalities, the improvement of our fellow men, and the sending abroad through all the channels which reach into our various communities those things which are useful, beneficial, and necessary for the well-being of the community. There are various obstacles which we meet in each department. I am so fortunate or unfortunate as to be placed at the head of a municipality, in which head all these various branches center, and from which must come the guiding influence which shall lead either to success or to failure and defeat. There are things which must be considered in connection with all these various departments, and it is the business of the chief executive to stand in such relation to the departments that the heads of those departments may be encouraged and assisted in their work for the full accomplishment of the best results. This burden presses itself upon the conscientious chief executive in any community continuously as he considers the various projects for municipal improvement and welfare; and I assure you that it is my personal sympathy with municipal departments which prompts me to assent to your President's request to speak to you to-night.

There is one thing which I think possibly may be of interest to you, and that is the effort which is being made, through the auditors

and through the mayors of the various cities, to secure a uniformity in the administration of municipal affairs. It has been my privilege to be the auditor of the city of Quincy from the time we assumed a city form of government, some eleven years ago. As the auditor, of course, I was a member of the Auditors' Club of Massachusetts. We have had the same difficulty in that organization which is experienced in any organization which only a comparatively small number of its members attend, but nevertheless the influence of our Auditors' Club has been felt all through the community. We exchange our various forms of accounts, we send to one another each month our statement of the standing of the finances of the various cities, we have one or two meetings a year at which we discuss the various problems which arise in connection with the keeping of the accounts; and, although the organization has been in existence only six years, its influence is strongly felt, and it has already resulted in an improved method of keeping accounts.

We early encountered this difficulty, that the difference in the charters of the various cities precluded uniformity in methods and made comparisons very difficult. Through some agitation on our part, and through the same spirit being awakened in the Mayors' Club of the State, there is an effort now being made to secure a uniformity of city charters, in order that all the requirements of the statutes may be complied with in a definite form, and in that way a uniformity in the treating of accounts will also be secured. And if the Auditors' Club and the Mayors' Club can have the assistance in this work of the water departments and of the highway departments, we shall be very glad.

One and all, we are working to improve the communities in which we live and to advance the best interests of the community at large, and of the individual members of it, by intelligent and conscientious effort. This is what we are all laboring for, and we can only accomplish the best results by united action.

Mr. President, I will not detain you longer. I thank you and the members of the Association heartily for the pleasure and profit of this past week.

The President then called upon Mr. Rudolph Hering, of New York, to speak upon the subject of sand filters.*

*Mr. Hering's remarks are printed as a discussion of Mr. Knowles' paper on the "Pittsburgh Filtration Experiments."

Mr. Frederick Law Olmsted, Jr., gave a talk upon "Landscape Problems in the Improvement of the Spot Pond Reservoir, Metropolitan Water Works," illustrated by the stereopticon.

Adjourned.

PROCEEDINGS.

November Meeting.

Young's Hotel,
Boston, November 14, 1900.

President Cook in the chair.

The following members and guests were present: —

Members.

Charles H. Baldwin, Lewis M. Bancroft, Joseph E. Beals, James F. Bigelow, Dexter Brackett, E. C. Brooks, Fred. Brooks, G. A. P. Bucknam, George F. Chace, E. J. Chadbourne, G. L. Chapin, L. Z. Carpenter, John C. Chase, Freeman C. Coffin, R. C. P. Coggeshall, Byron I. Cook, J. W. Crawford, August Fels, Harry F. Gibbs, J. F. Gleason, Albert S. Glover, F. W. Gow, E. H. Gowing, George W. Harrington, William E. Hawks, Horace G. Holden, Willard Kent, Patrick Kieran, A. E. Martin, Frank E. Merrill, Thomas Naylor, C. E. Riley, A. H. Salisbury, Charles W. Sherman, W. H. Sears, J. A. St. Louis, Henry Souther, Robert J. Thomas, William H. Thomas, George W. Travis, D. N. Tower, W. H. Vaughn, William W. Wade, Charles K. Walker, Elbert Wheeler, George E. Winslow.

Associates.

Ashton Valve Co., by C. W. Houghton; International Steam Pump Co., by George J. Foran; Ingersoll-Sergeant Drill Co., by Mellen S. Harlow; Hersey Mfg. Co., by James A. Tilden and Albert S. Glover; Lead Lined Iron Pipe Co., by Thomas H. Dwyer; Neptune Meter Co., by H. L. Kinsey; Perrin, Seamans & Co., by Harold L. Bond; Rensselaer Mfg. Co., by Fred S. Bates; Builders' Iron Foundry, by H. J. Burrough and F. N. Connet; A. P. Smith Mfg. Co., by W. H. Van Winkle; Sumner & Goodwin Co., by Frank E. Hall; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by J. K. P. Otis; United States Cast Iron Pipe & Foundry Co., by John M. Holmes.

Guests.

John F. Farrar, Lincoln, Mass.; H. Walter Gay, Quincy, Mass.; A. F. Hall, Marlboro, Mass.; Caleb Lothrop, Registrar, Cohasset, Mass.; George H. Snell, Superintendent, Attleboro, Mass.; F. L. Weaver and M. J. Dowd, Water Commissioners, Lowell, Mass.

The Secretary read the following names of applicants for membership: —

For Resident Member.

John F. J. Mulhall, Boston, Treasurer of the Portland, Conn., Water Co., and Secretary and Director of various water companies; Lyman P. Hapgood, Superintendent Athol Water Co., Athol, Mass.

For Non-Resident Member.

John Andrew Amyot, M.D., Toronto, Canada, Bacteriologist and Analyst to the Provincial Board of Health of Ontario, Canada; A. M. Miller, Lieutenant-Colonel Corps of Engineers, U. S. A., in charge of the Washington Aqueduct, and of the work of increasing the water supply and constructing the filtration plant of Washington, D. C.; J. J. Smith, C.E., Grand Forks, N. Dak.

On motion of Mr. Coggeshall, the Secretary was instructed to cast the ballot of the Association in favor of the applicants named above, and they were declared elected to membership.

President Cook then read a paper on "Electrolysis," prepared by F. A. W. Davis, Vice-President and Treasurer of the water company, Indianapolis, Ind., who was unable to be present.

Mr. W. J. Sando, formerly Superintendent of Pumping Stations, Metropolitan Water Board, Boston, submitted a "Report of Contract Trial of Thirty Million Gallon Pumping Engine at the Chestnut Hill High Service Pumping Station of the Metropolitan Water Works," which was read by Mr. Charles W. Sherman.

The subject for topical discussion was "Service Boxes," and the discussion was participated in by President Byron I. Cook, of Woonsocket, R. I.; Superintendent A. E. Martin, of South Framingham; Superintendent Charles K. Walker, of Manchester, N. H.; Superintendent Frank E. Merrill, of Somerville; Superintendent R. C. P. Coggeshall, of New Bedford; Mr. F. N. Connet, of the Builders' Iron Foundry; Superintendent Horace G. Holden, of Nashua; Mr. C. W. Sherman; Superintendent Lewis M. Bancroft, of Reading; Superintendent D. N. Tower, of Cohasset; Mr. George E. Winslow, of Waltham; Superintendent Robert J. Thomas, of Lowell; Superintendent Geo. W. Travis, of Natick; Superintendent Frederick W. Gow, of Medford; and Mr. J. F. Gleason, of Quincy.

STANDARD SPECIFICATIONS FOR WATER PIPE.

MR. E. H. GOWING. I read with some interest Mr. Coffin's paper before the Association last spring in which he referred to standard specifications for water pipe. I think Mr. Coffin wrote a very good paper, but I believe he stopped a little short of the point to which he should have gone. I suppose it was his modesty which made him do so. But I am not so modest as he is, and I think we ought to take some action on this subject, and I would like to ask whether the better way would be to have it brought up for topical discussion some time later in the season, or for me to make a motion now to have a committee appointed to take up the matter on the lines indicated by Mr. Coffin's paper.

THE PRESIDENT. I would say, Mr. Gowing, that in my address at Rutland, I alluded to this matter as something which should be taken up by the Association. Possibly it would be a good idea to have a committee appointed to confer with Mr. Coffin, and have the subject brought up for discussion at some subsequent meeting, with a view to issuing standard specifications, to be called the New England Water Works Specifications for Cast-Iron Pipe, so they can be referred to in calling for bids.

MR. GOWING. Mr. Coffin said a good many things in favor of it, and I am strongly in favor of that idea. I will make a motion that the President appoint a committee to take up this matter, perhaps to call for a discussion during the winter, and then later to make us a report; or, perhaps it would be better, and I will make this motion instead, that the President appoint a committee to consider the subject along the lines of Mr. Coffin's paper, and then let the committee be at liberty to do as they see fit.

Adopted.

The President said he would appoint the committee at the next meeting, and that the subject would be considered at either the February or March meeting.

Adjourned.

OBITUARY NOTES.

HENRY CHANDLER, Clerk of the Water Board of Manchester, N. H., as well as its most prominent member, died October 19, 1900. He was also a Director in the Manchester Manufacturing Company, and Cashier of the Amoskeag National Bank. He had shown great interest in all matters connected with water works.

Mr. Chandler was elected a member of the New England Water Works Association on September 13, 1895.

EX-MAYOR GEORGE S. JENKINS, of Lawrence, Mass., who was a member of the Lawrence Water Board for the five years 1894–1898 inclusive, died November 12, 1900. He was elected a member of this Association on February 12, 1896.

INDEX TO ADVERTISEMENTS.

ADVERTISEMENTS. PAGE

Journal of the New England Water Works Association xviii

BRASS GOODS.

The Peck Brothers & Co vi
Walworth Manufacturing Co vii

CAST IRON PIPE AND SPECIALS.

Builders Iron Foundry xv
Donaldson Iron Co xii
M. J. Drummond & Co xiv
U. S. Cast Iron Pipe & Foundry Co xiii
Warren Foundry and Machine Co xiv
R. D. Wood & Co. x

CEMENT.

Lawrence Cement Co xviii

FILTERS.

New York Filter M'f'g Co xv

FURNACES, ETC.

Perrin, Seamans & Co xvii

GATES, VALVES, AND HYDRANTS.

Ludlow Valve M'f'g Co xii
Sweet & Doyle xi
Walworth M'f'g Co xii
R. D. Wood & Co x

LEAD AND PIPE.

Boston Lead M'f'g Co ix
Chadwick Lead Works viii
Lead Lined Iron Pipe Co ix

METERS.

Hersey M'f'g Co iii
National Meter Co ii
Neptune Meter Co vi
Thomson Meter Co iv
Union Water Meter Co v
Venturi Meter xviii

PACKING.

The Gould Packing Co xvii

PUMPING ENGINES.

The Edward P. Allis Co xvi

TAPPING MACHINES.

Walworth M'f'g Co vii

TOOLS AND SUPPLIES.

Perrin, Seamans & Co xvii

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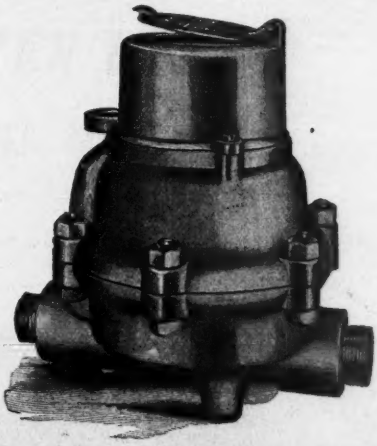

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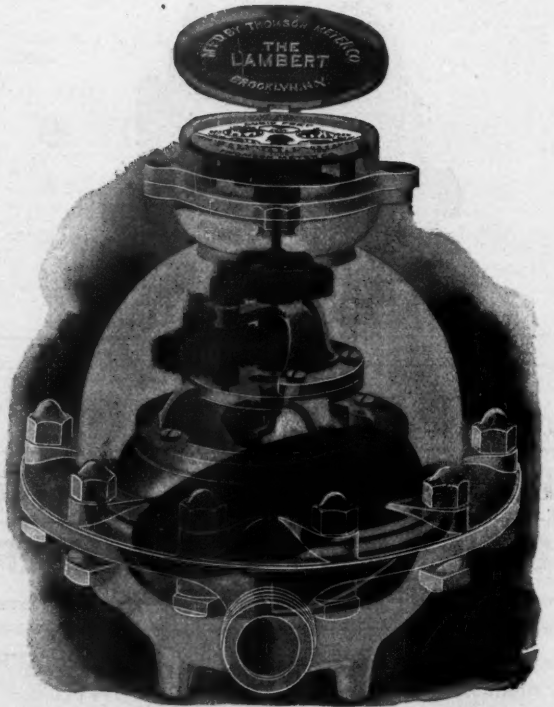

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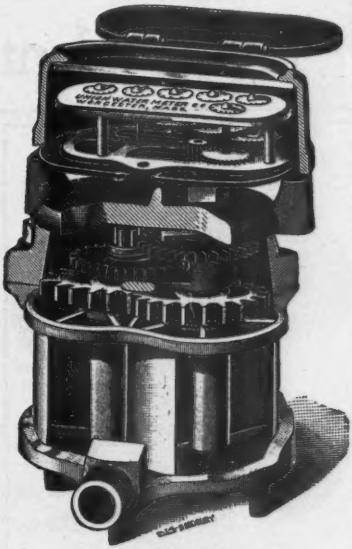

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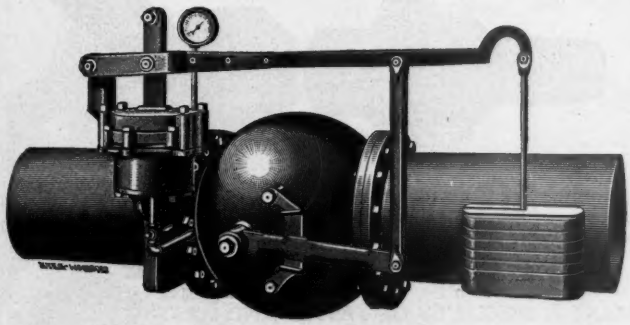

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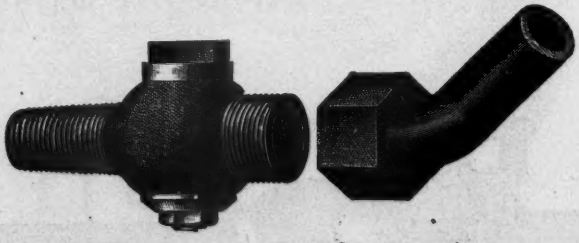

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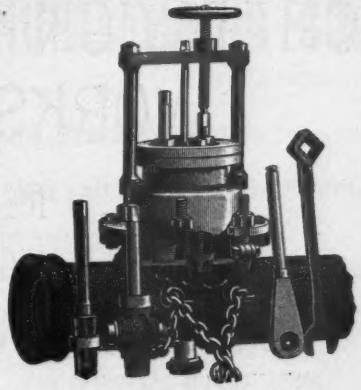

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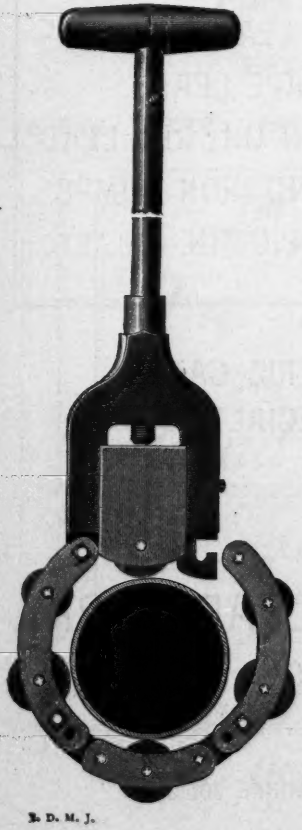

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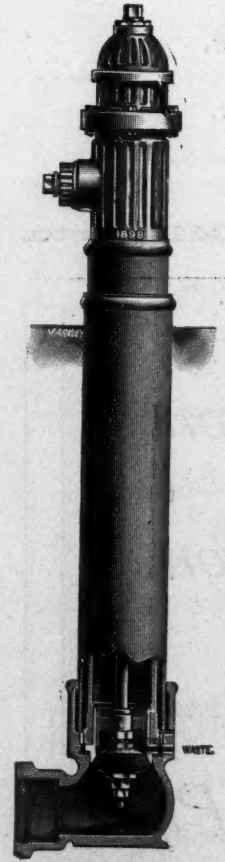

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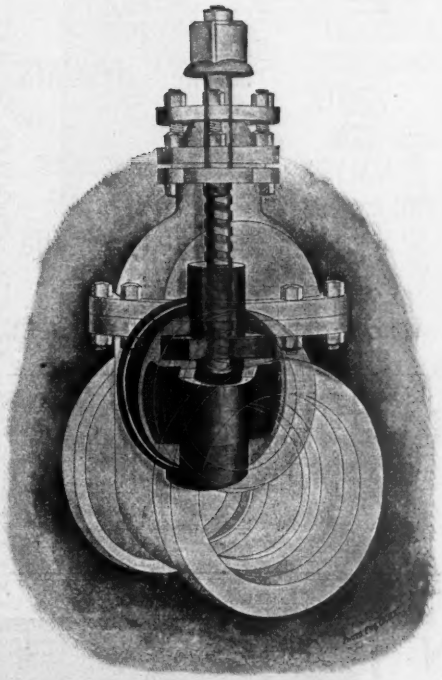

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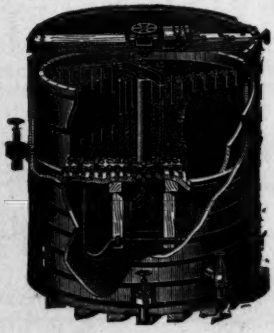

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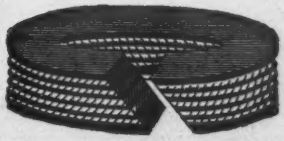

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